Iron AND Steel ENGINEER

ENGINEERING SERVICE
TO THE IRON AND STEEL
INDUSTRY SINCE 1907

JULY, 1954 TECHNOLOGY DEPT.

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JUL 2 1954
DETROIT

The WEAN ENGINEERING
COMPANY, Inc.
WARREN OHIO

IR v. 31² Jy-D'54

NEW! CUTLER-HAMMER
BULLETIN 11011
UNBREAKABLE,
ALL-WELDED RESISTORS

Lower Maintenance Costs, More Stable Resistance Values, Higher Current Capacities

Cutler-Hammer now offers a brand-new unbreakable mill-type resistor with design features that provide an all-welded current path, that stabilize resistance values, afford high current capacities, and resist corrosion and vibration.

The individual grids are punched from a chromium steel alloy and are mounted in an unique over-under arrangement to attain exceptionally efficient heat radiation which permits continuous current capacities up to 180 amperes per box. The low resistance coefficient of the grid alloy results in small resistance change despite grid temperature variation. Grid junctions are seam welded and terminal taps spot welded to insure a continuous current path and to eliminate grid contact troubles. Rugged steel and mica washers are used as grid spacers and insulators.

A radically new type of end plate and grid rod design affords "draw-out" replacement of the grid assembly without disturbing the end plates or other boxes in the resistor stack. This exclusive construction feature also compensates for thermal expansion of the individual grids.

These resistors are available in ratings from 1/10th to 10 ohms. Standard boxes come in 17", 22½" and 28" lengths. Terminals provide 10% resistance steps. All resistors are insulated for 600 volt service.

For lower maintenance costs, more stable resistance values, and higher current capacities *standardize on these new Cutler-Hammer Bulletin 11011 Unbreakable Resistors.* Cutler-Hammer, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

CUTLER-HAMMER
MOTOR CONTROL
C-H

IRON AND STEEL ENGINEER: published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress, March 3, 1879. $7.50 per year in United States and Canada, $10.00 foreign countries. Volume 31, No. 7

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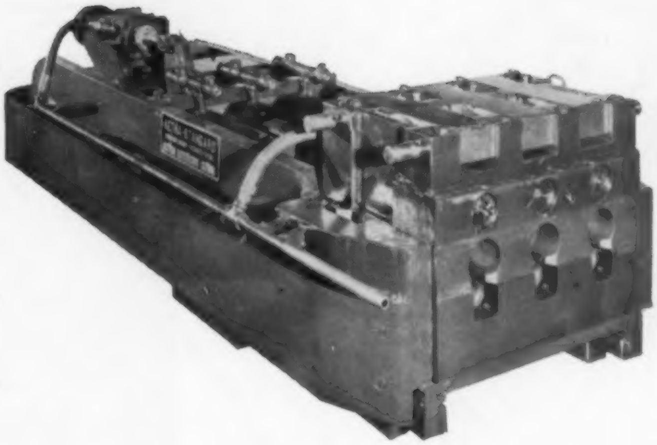
announcing . . .

NEW DRAWBENCH DEVELOPMENT

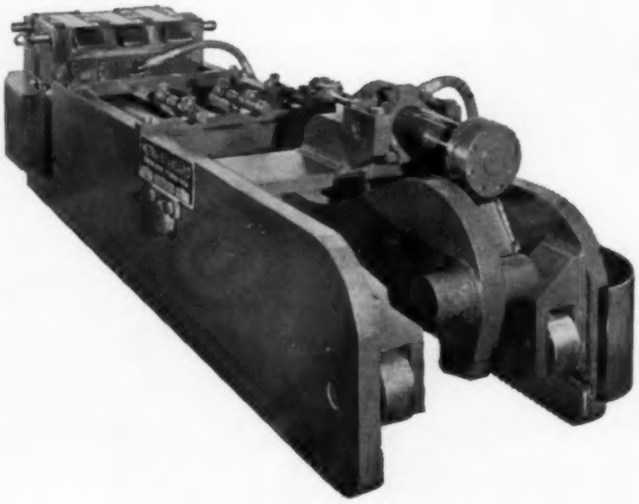
AIR

OPERATED CARRIAGES

AND HOOK



Says an Aetna drawbench customer—"Applying air to the carriages and hook is the greatest thing you have ever done for me."



Aetna has equipped ten benches with air-operated carriages and hook. What about yours?

positive gripping . . .
positive hooking . . .

● Tubes can be drawn at least six inches before air pressure releases the gripping cylinders. This six-inch margin assures a positive grip on tubes. Another advantage — the use of air permits close-up gripping to die stand although the carriage action does not require actual contact with die stand.

Both the carriage and air hook cut down on breakage and maintenance because they eliminate the chief cause — slam-bang action. The cylinder lets the hook down gently and smoothly.

Air-operated carriages, which include many patented features, can be adapted to existing benches of any size. Aetna has interchangeable heads for Aetna's own benches or can adapt the new head to existing benches of other makes. The air-operated heads and hooks can be used for single, double, triple, four- or five-draw.

THE AETNA-STANDARD ENGINEERING COMPANY • PITTSBURGH, PA.

Aetna-Standard

PLANTS IN WARREN, OHIO • ELLWOOD CITY, PENNSYLVANIA

GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

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Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.
M. Castellvi, Inc., New York, N. Y. — Mexico, Central and South America.
Societe de Constructions de Montbard, Paris, France — France, Belgium, Holland, Luxembourg, Switzerland.
Demag Aktiengesellschaft, Duisburg, Germany — Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.
Compagnia Italiana Forme Acciaio, Milano, Italy — Italy.
Aetna-Japan Company, Ltd., Tokyo, Japan — Japan.
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LADLE CRANE
OPERATED BY**

**EC&M
CONTROL**

Ask the men who operate the "big ones" . . . they'll tell you that they prefer EC&M Control because of easy and simplified operation. They know from experience that these tried, tested and proven crane controllers have the highest reputation for reliability.

You don't have to have the world's largest Ladle Crane to utilize the advantages of the EC&M Wright Circuit hoist controller. Here is a unit that guarantees the operator complete control from the master switch of all loads in the lowering direction . . . applies down-power quickly through fast operating LINE-ARC Contactors for instantaneous brake release, making it easy to spot heavy loads . . . on cranes of any size.

Key to EC&M superiority in safety, efficiency and economy is simplicity . . . simplicity reduces need for maintenance, assures complete understanding, encourages regular inspection and promotes safer operation.

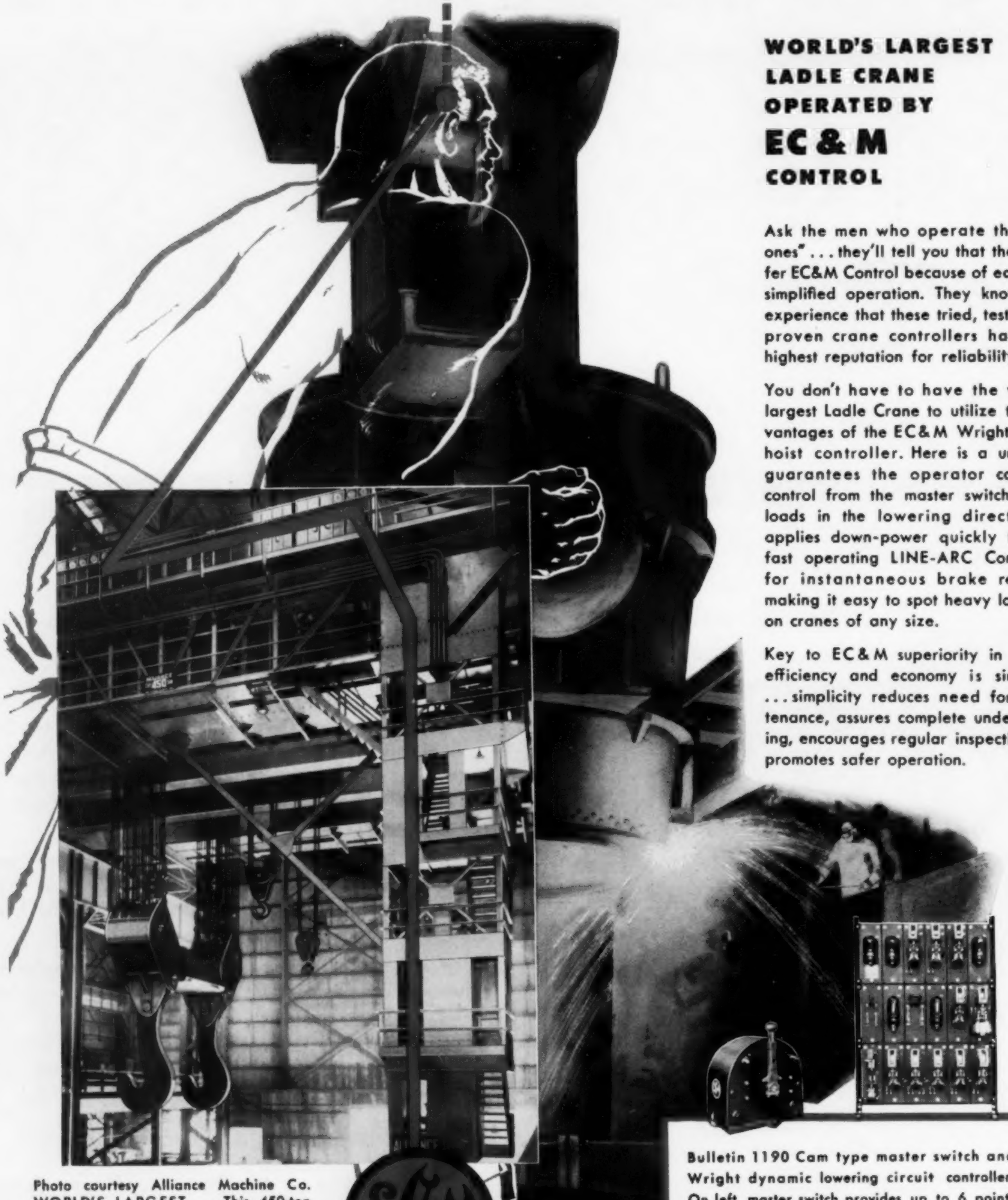

Photo courtesy Alliance Machine Co. WORLD'S LARGEST . . . This 450-ton 4-girder ladle crane has 69'6" span and is positively and accurately operated by EC&M controls.

Bulletin 1190 Cam type master switch and Wright dynamic lowering circuit controller. On left, master switch provides up to 6 points of speed control.

THE ELECTRIC CONTROLLER & MFG. CO.

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1770

MORGANIZATION...way to cut costs

They expected a minimum of 20 years of service from the special-purpose Morgan crane we built for their steel mill. Already this steel company has received 39 years of service, almost double the expected life... and the end is still nowhere in sight. And, of course, the yearly expected cost of operating the crane has been reduced.

This is a typical result of "Morganization"... surveying, designing, building, and installing with the experience and *extra care* that make Morgan cranes and rolling mills and special equipment *last a lot longer*... and that make Morgan equipment cost less over those added years.

Write for booklet E-7, which describes "Morganization" and Morgan equipment for heavy service.

MORGAN ENGINEERING

THE MORGAN ENGINEERING COMPANY, ALLIANCE, OHIO

Our Rolls are
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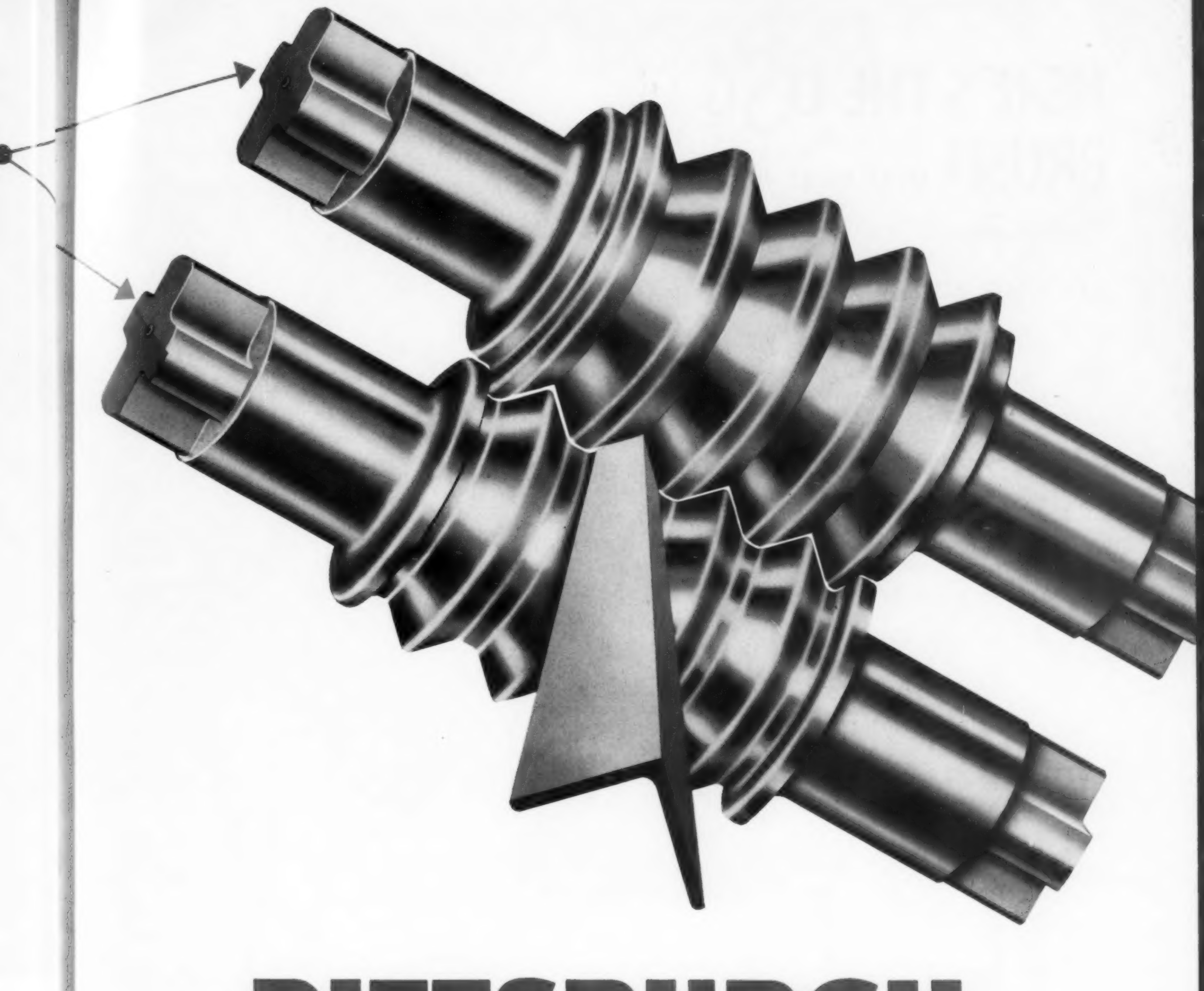
applications

"the right roll in the right stand"

. . . requires fewer roll changes

The practical experience and technical know-how to achieve fewer roll changes are readily available through our roll engineers . . . who will be glad to consult with you in the selection of the *right* roll for *each* application in your mill.

BLAW-KNOX



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BLAW-KNOX COMPANY • ROLLS DIVISION • PITTSBURGH ROLLS DEPARTMENT
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Continental designs and builds complete rolling mills including all auxiliary equipment. *For flat rolling:* slabbing, universal, plate, hot strip, cold strip and temper mills. *For shape rolling:* blooming, structural, rail, billet, rod and merchant mills.

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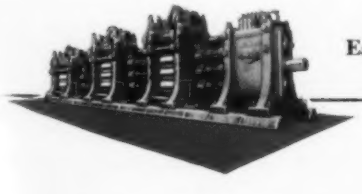

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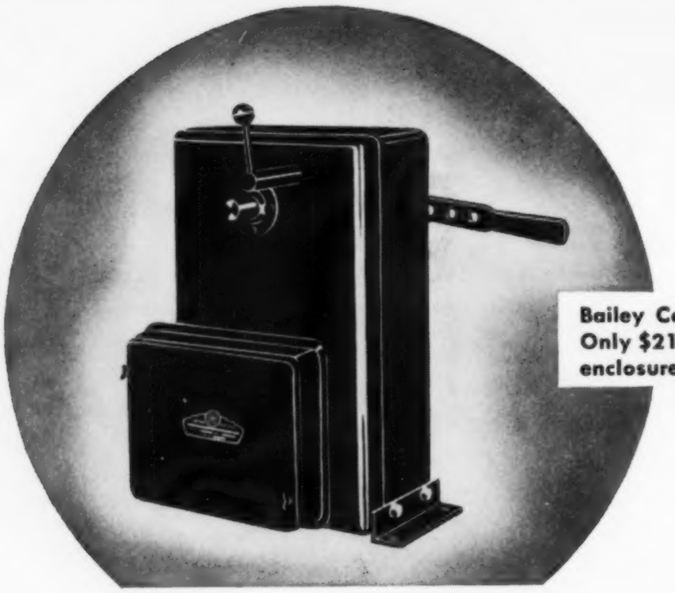


Bailey Control Drive, Type AC44P Model 200. Only $210.00 F. O. B. Cleveland, complete with enclosure, positioning relay and hand operator.

Want Better Flow Characteristics from Your Regulating Devices?

This new, small, piston-operated Bailey Control Drive will improve the flow characteristics of butterfly valves, dampers, hydraulic couplings, feeders and similar regulating devices. Adjustment is simple; any desired relation between drive motion and pneumatic signal may be secured.

You can install this compact pneumatic drive power unit in any position on a column, pipe, or flat surface—and connect it to the regulating device with standard Bailey linkage, available from stock.

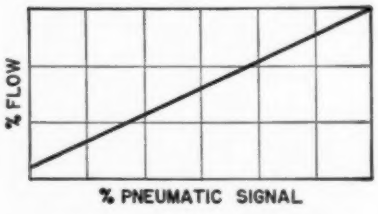
Speed (time required for full travel) is adjustable to suit your requirements. Bailey Control Drives operate on standard SAMA pneumatic signal ranges of 3 - 15 or 3 - 27 psig.

AVAILABLE FROM STOCK in 3 standard sizes

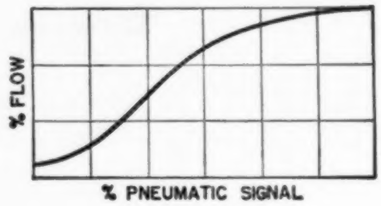
Type	Piston Dia. Inches	Piston Stroke Inches	Torque ft-lb	Max. Travel Degrees	Approx. Dimensions Inches
AC816	8	16	1500	90	13 x 27 x 51
AC68	6	8	400	90	13 x 19 x 34
AC44	4	4	75	75	10 x 11 x 19

P-28

The New Bailey Control Drive gives you THIS—



instead of THIS



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Complete Controls for Process Plants

Controls for
TEMPERATURE
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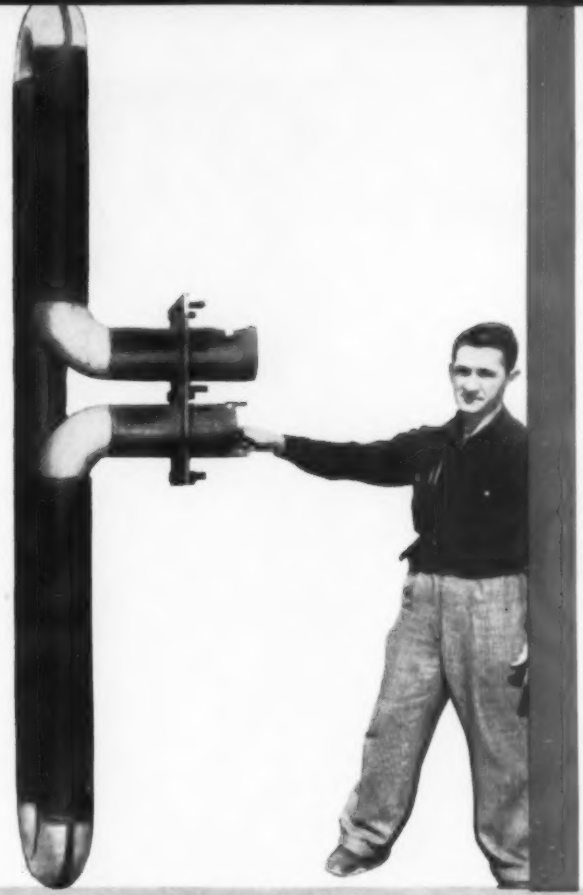
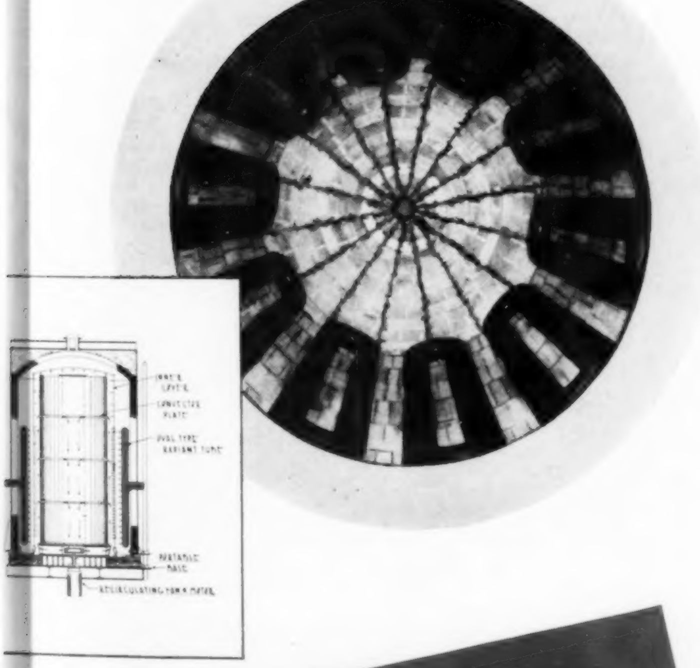
☐ **I am interested in Bailey Control Linkage. Mail me Spec. CA942B.**

Name____________________
Title & Company____________________
Street & Number____________________
City & Zone____________State______

here's the amazing "O" tube



that reduced annealing costs



The remarkable efficiency of the Lee Wilson Single-Stack Portable-Base Annealing System is due in a great degree to the new "O" type radiant tube. The tube, developed by Lee Wilson especially for the bell type furnace, is an engineering accomplishment.

The design of the tube allows greater length of flame travel and the fuel application is so arranged that the principal heat release is in the bottom of the tube. The flame, however, is continued around the top elbow, changing the direction of the gas flow, keeping the primary combustion near or on the tube surface, effecting more efficient heat transfer. The sharp turns designed into the tube not only make it a compact, space-saving unit but create a gas turbulence at the elbows that promotes more rapid combustion; thus, more of the tube is working. The "O" Tube has a much greater dispersion area than other tubes and can operate at an input of 500,000 BTU per tube, per hour.

The design of the tube also permits perfect blanketing of inner cover, speeding heating time and eliminating hot and cold spots. Structurally, the tube has the advantage of not requiring holes in the furnace arch and but one opening in the side wall. It is free to expand in every direction, preventing excessive force which might crack the joints.

There's a lot more to the story! Performance records prove this tube has no equal when it comes to quality production annealing. It's the furnace of the future — here today. Brochure and data sheets available upon request.

Lee Wilson

ENGINEERING COMPANY, Inc.

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Depend on "YOUNGSTOWN"

DRIVEN SLITTER
Capacity 4 cuts in 67" wide x .375" thick Hot Rolled Strip Steel

F&YM

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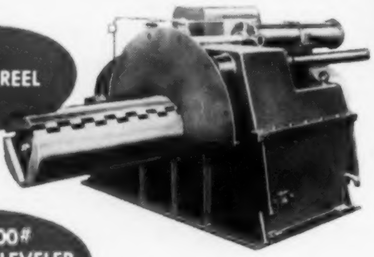
STRIP MILL MACHINERY

Precision-built and engineered to your needs and specifications



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90"x 240"x ¼" thick

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- CONTINUOUS PICKLING LINES
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- PAY OFF REELS
- TAKE UP REELS
- UP CUT SHEARS
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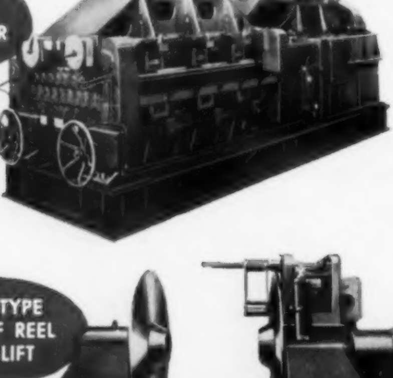
- COIL CARRIAGES
- UP ENDERS
- DOWN ENDERS
- EDGING MILLS
- TABLES
- CLASSIFIERS & PILERS
- SCRAP BALLERS



BACKED UP
ROLLER LEVELER

Write for Complete Information

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WITH LIFT

The Youngstown Foundry & Machine Co.

SERVING INDUSTRY SINCE 1885

Youngstown, Ohio

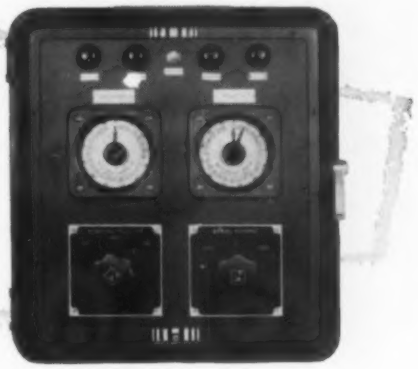
17

For highest OH air-preheat . . .

L&N OFFERS YOU 3 INSTRUMENTATION PROGRAMS

Efficient operation of regenerative furnaces demands reliable instrumentation, to assure balanced reversal of firing for highest average air-preheat. To suit your specific preferences, L&N offers a choice of equipment which can be readily adapted to your present installation.

1. If you require a reliable indication and record of checker temperatures only, as a guide to manual reversals, the strip-chart Model S Speedomax recorder measures two, four, or six temperature points, detected by thermocouples or Rayotube (radiation-type) detectors sighting directly on the brick.



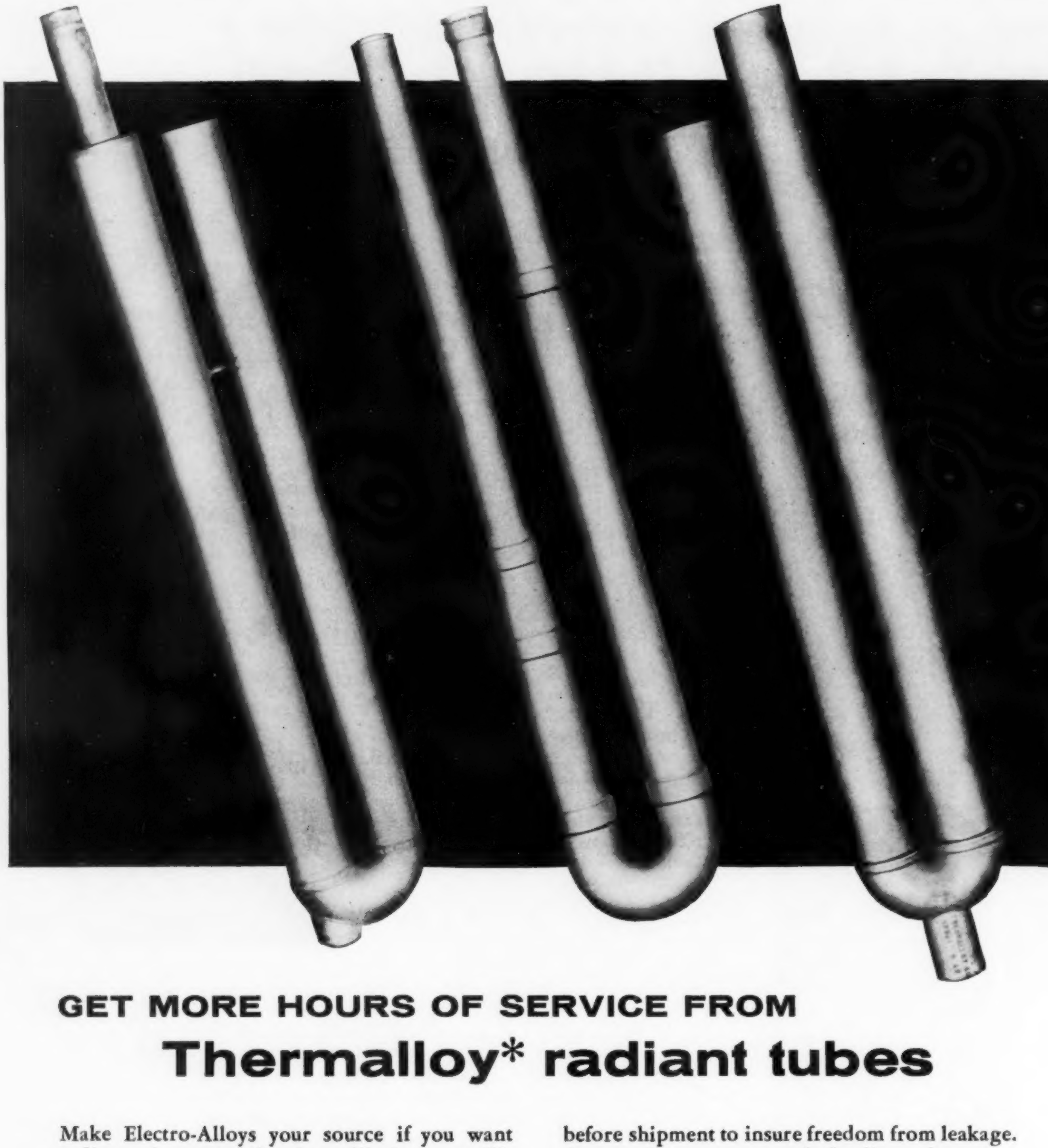
2. If you require automatic reversal of firing on the basis of time alone, the L&N Master Reversal Control Unit compactly houses all essential elements in one case—timers, signal lights, relays, and switches to select automatic or manual operation.

3. If you require a completely flexible system, the Master Reversal Control Unit combined with a Speedomax Temperature-Temperature Difference Recorder-Controller offers a choice of automatic reversal based on time, temperature difference, or temperature difference *or* time, as well as manual reversal.

The Speedomax instrument charts a continuous two-point record of checker temperatures—detected by thermocouples or Rayotube detectors—and can initiate reversal on the basis of pre-set temperature difference . . . functions which normally require *two* conventional instruments.

Full details of this equipment are available on request. Simply contact our nearest office, or write us at 4942 Stenton Ave., Philadelphia 44, Pa.

LEEDS NORTHRUP
instruments *automatic controls • furnaces*



GET MORE HOURS OF SERVICE FROM
Thermalloy* radiant tubes

Make Electro-Alloys your source if you want radiant tube assemblies that will give more life and reduce maintenance costs.

All components are produced in suitable analyses under close metallurgical supervision, and with X-ray control. The straight tube sections are centrifugally cast in such a way that wall thickness is uniform throughout; i. e., inside diameter and outside diameter are concentric, and thickness is the same the full length of the tube. All finished assemblies are pressure-tested before shipment to insure freedom from leakage. As a result, you are assured of radiant tube assemblies that last longer without cracking, warping or sagging.

Whatever your needs in radiant tube assemblies or other heat-treating equipment—you'll get more operating economy from high heat-resistant Thermalloy castings. Let us know your requirements. Call your nearest Electro-Alloys engineer or write Electro-Alloys Division, 5006 Taylor Street, Elyria, Ohio.

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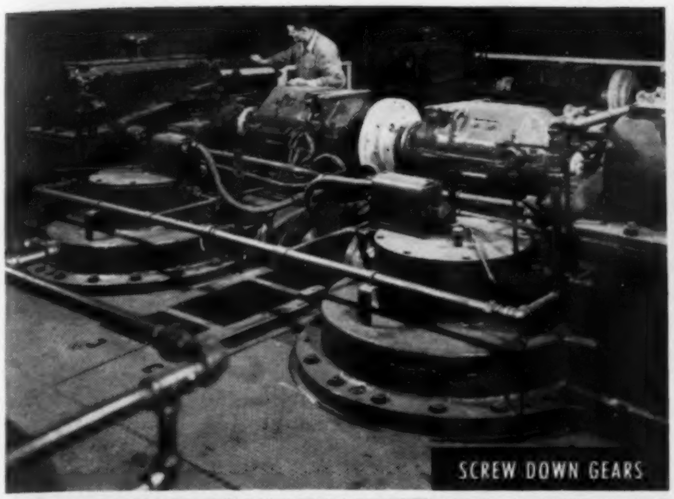

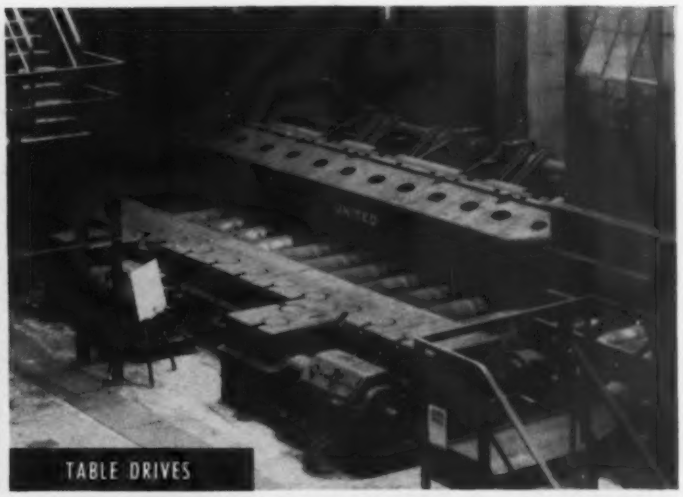

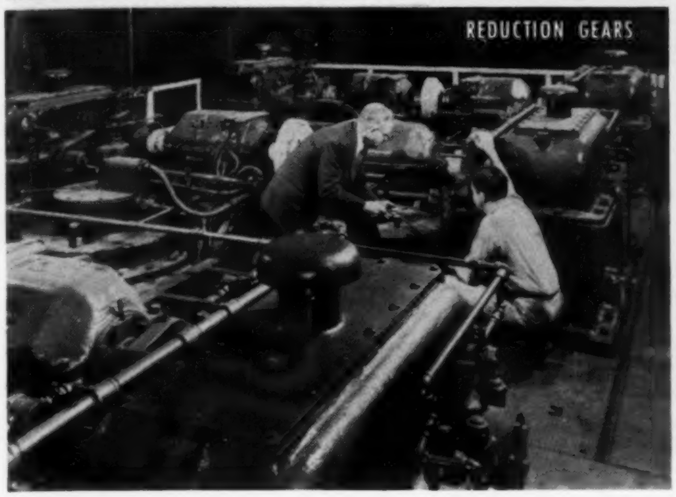

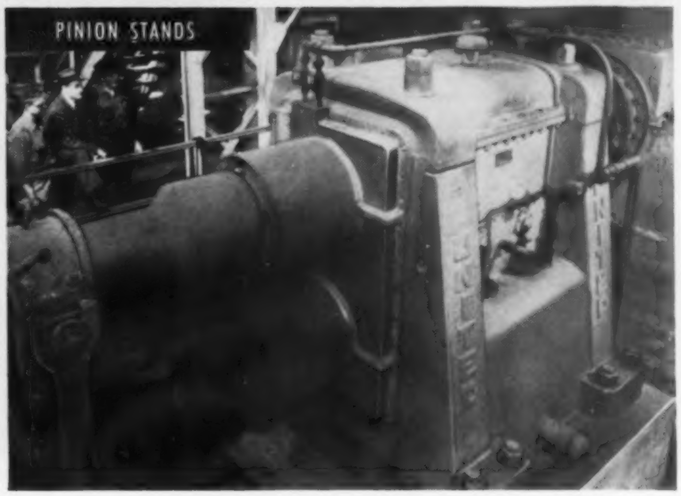

Get protection *plus* for your gear drives with GULF E.P. LUBRICANTS

Get the advantage of the extra load-carrying capacity of Gulf E.P. Lubricants, plus excellent water separating and rust preventive properties, plus exceptional stability for this type of lubricant, plus effective nonfoaming and noncorrosive characteristics.

This "plus protection" of Gulf E.P. Lubricants not only prevents excessive gear wear but insures freedom from rust, foaming, and other lubrication troubles.

The next time you order gear drive lubricants, make it an order for safe, sure protection and lower maintenance costs — specify Gulf E.P. Lubricants.

For more complete information, or for expert help on your gear drive lubrication problems, send the handy coupon.

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Gulf Oil Corporation · Gulf Refining Company
1822 Gulf Building, Pittsburgh 30, Pa.

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I would like further information on Gulf E.P. Lubricants:

☐ Please have a Gulf Sales Engineer call. ISE

☐ Please send me a copy of your pamphlet "Gulf E. P. Lubricants for Reduction Gear Drives."

☐ Please arrange to show a group in our plant the new Gulf Color Slide Film, "Gears and Their Lubrication."

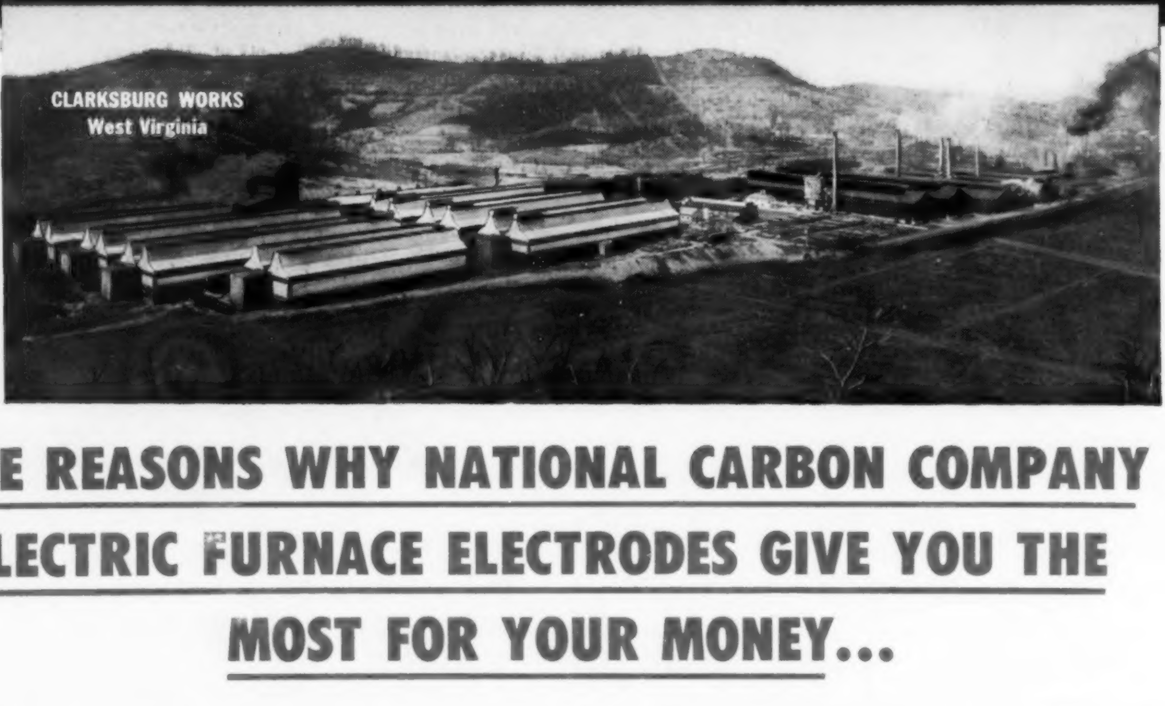
Name__________

Company__________

Title__________

Address__________

TENNESSEE WORKS
Columbia, Tenn.



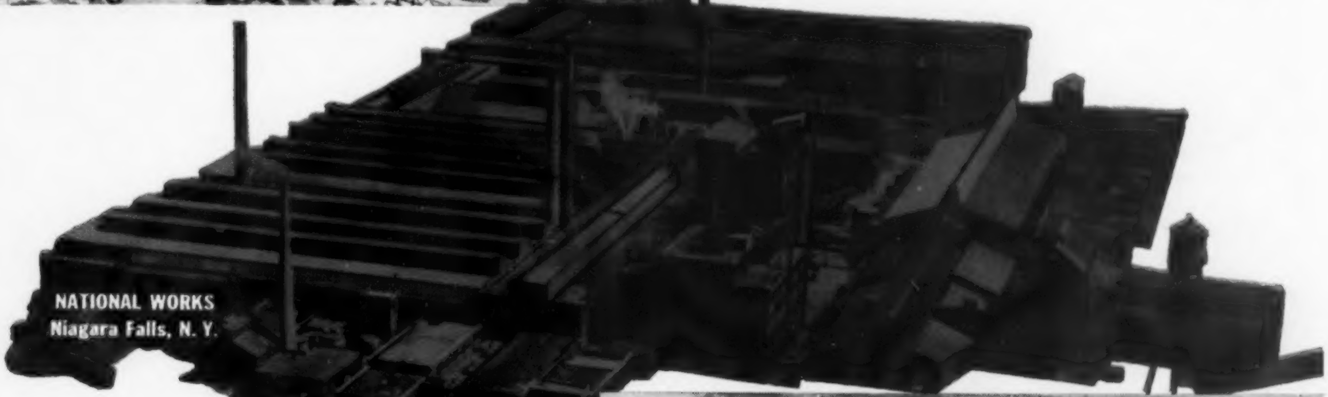
FIVE REASONS WHY NATIONAL CARBON COMPANY ELECTRIC FURNACE ELECTRODES GIVE YOU THE MOST FOR YOUR MONEY...

ELECTRODE QUALITY... has a direct bearing on the quality of *your* product; in many instances, it can materially affect your *cost.* National Carbon's graphite and carbon electrodes are, and always have been, the finest quality obtainable *anywhere.* We make this statement without reservation.

NEW PRODUCT DEVELOPMENT... is basic in technological progress. National Carbon has *always* done the major part of this country's electrode research and development... a share out of all proportion even to its outstanding leadership in the production and sale of these products. This is a matter of long-standing record.

ACHESON WORKS
Niagara Falls, N. Y.

PLANT CAPACITY . . . National Carbon's ability to *produce* is at an all-time high. The five plants shown here are fully integrated for production of both carbon *and* graphite electrode products — a situation rare in the industry and in keeping with National Carbon's far-sighted planning to pace requirements of a rapidly-expanding economy. For example, plant additions in the last five years alone have more than doubled graphite electrode capacity.



REPUBLIC WORKS
Niagara Falls, N. Y.

EXPERIENCE . . . of National Carbon is the foundation, building blocks and cornerstone of electrode-products manufacture in this country. First with commercial production of both carbon and graphite electrodes in the early 1900's, National Carbon introduced the first of each increasingly larger electrode size from that time to the present, plus a host of successful accessory items for improved application of electrodes in the metallurgical field. Today, National Carbon is the only company producing carbon electrodes up to 45″ diameter; graphite electrodes to 35″. Even larger electrodes and other massive shapes can be made with present facilities. Inquiries are invited.

RESPONSIBILITY . . . to customers and to the industry as a whole . . . expresses itself several ways in National Carbon history. The company has consistently kept ahead of demands for both quality and size of electrode products; National Carbon research stands virtually alone in the steady march of new product development; and, in the field of *service,* National Carbon is supreme. For many years we have conducted an expanding, electrode technical-service operation, staffed by a group of electrode experts, specially trained to help you get ***more for your electrode dollar.***

The terms "National" and "Acheson" are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY

A Division of
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30 East 42nd Street, New York 17, N. Y.

District Sales Offices:
Atlanta, Chicago, Dallas, Kansas City,
New York, Pittsburgh, San Francisco

IN CANADA:
Union Carbide Canada Limited, Toronto

New straightener automatically adjusts for different size tubes and bars

. . . has 40 TIMKEN® bearings

WHEN you switch from one size bar or tube to another, this new Sutton straightener automatically adjusts its straightening rolls to take the new size. This enables you to switch from 1¼" O.D. tube to 3¾" in less than a minute and a half!

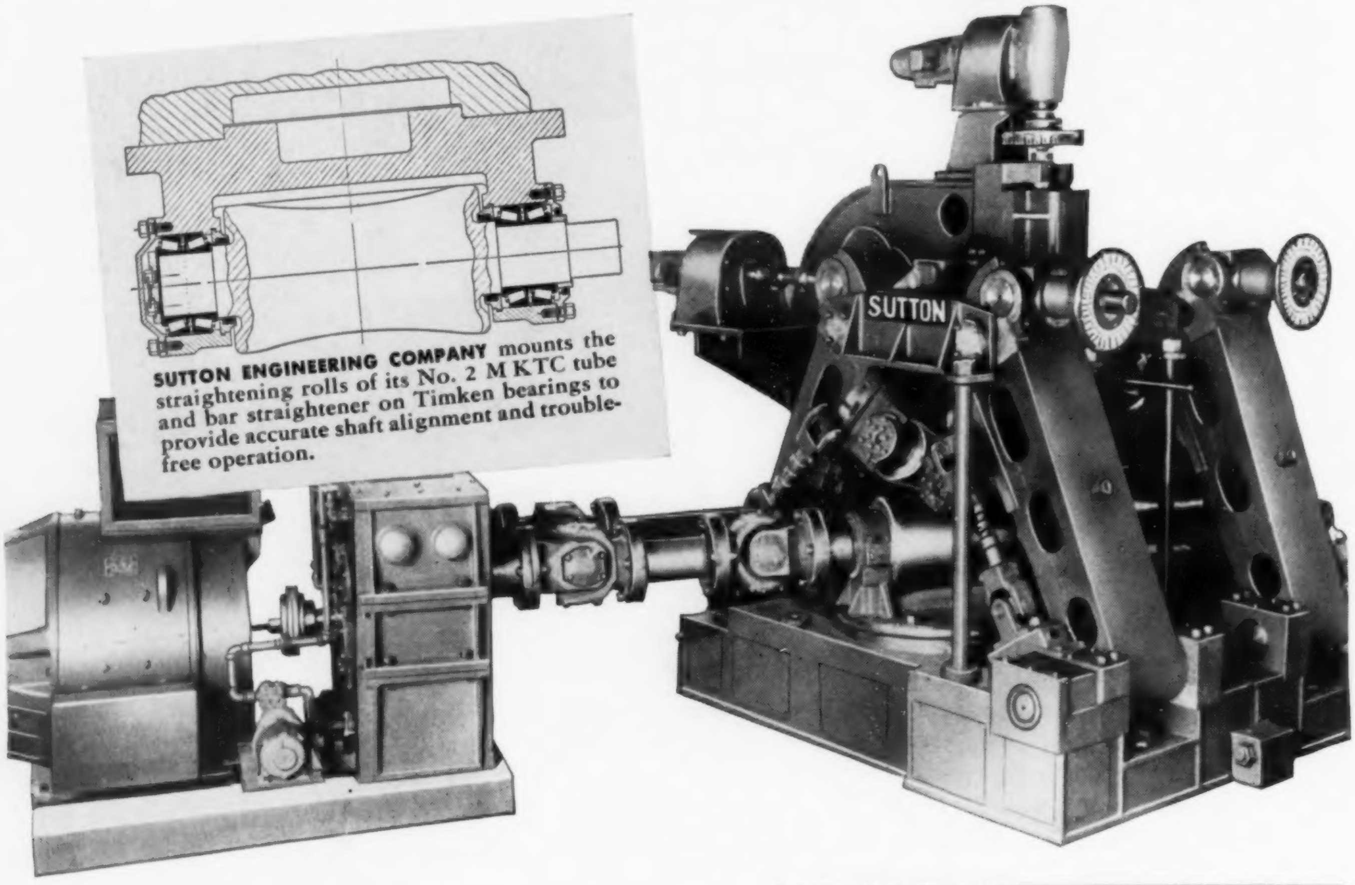
Because straightening rolls must withstand heavy radial and thrust loads as the work passes through, they are mounted on Timken® tapered roller bearings. The taper enables the bearing to take both radial and thrust loads. Line contact between rollers and races gives them high load-carrying capacity. The net result is accurate shaft alignment and trouble-free operation.

This straightener uses a total of 40 Timken bearings—in the idler rolls, universal joints, and drive unit as well as the driven rolls. Space is at a premium and the compactness of Timken bearings is a big advantage. Their high load-carrying capacity permits a relatively small-size bearing. And no space-taking thrust bearings are required.

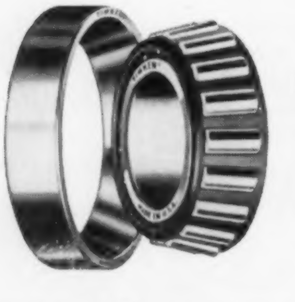
Timken bearings minimize friction because they have true rolling motion and *incredibly* smooth surface finish. This helps provide a smooth-running machine despite the heavy variable loads. It also means longer life and minimum maintenance.

Timken bearings are a sure sign of quality on the machines you buy and the machines you build. Look for the trade-mark "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable: "TIMROSCO".

This symbol on a product means its bearings are the best.



SUTTON ENGINEERING COMPANY mounts the straightening rolls of its No. 2 M KTC tube and bar straightener on Timken bearings to provide accurate shaft alignment and trouble-free operation.



TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

DESIGN LEADERSHIP

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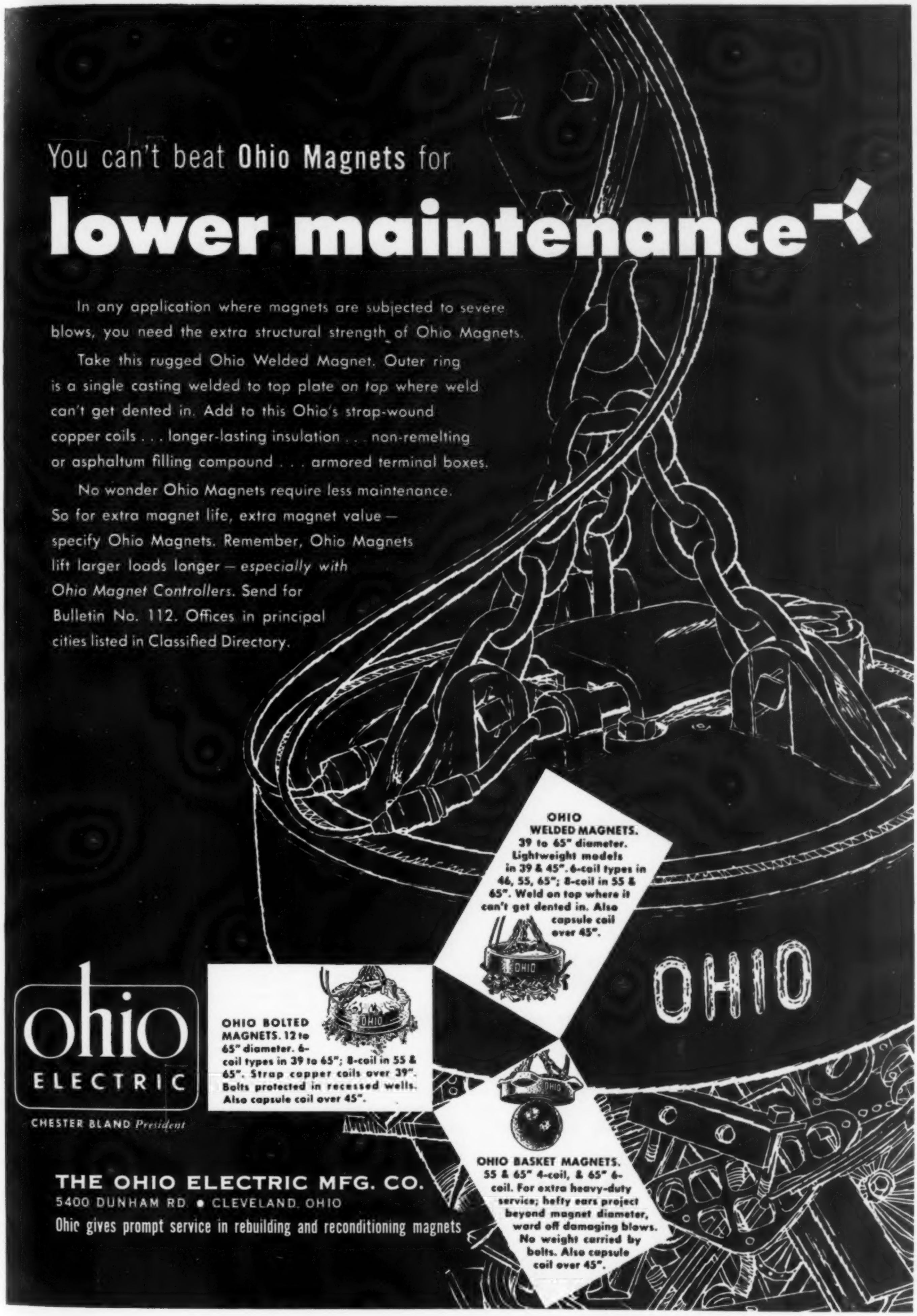

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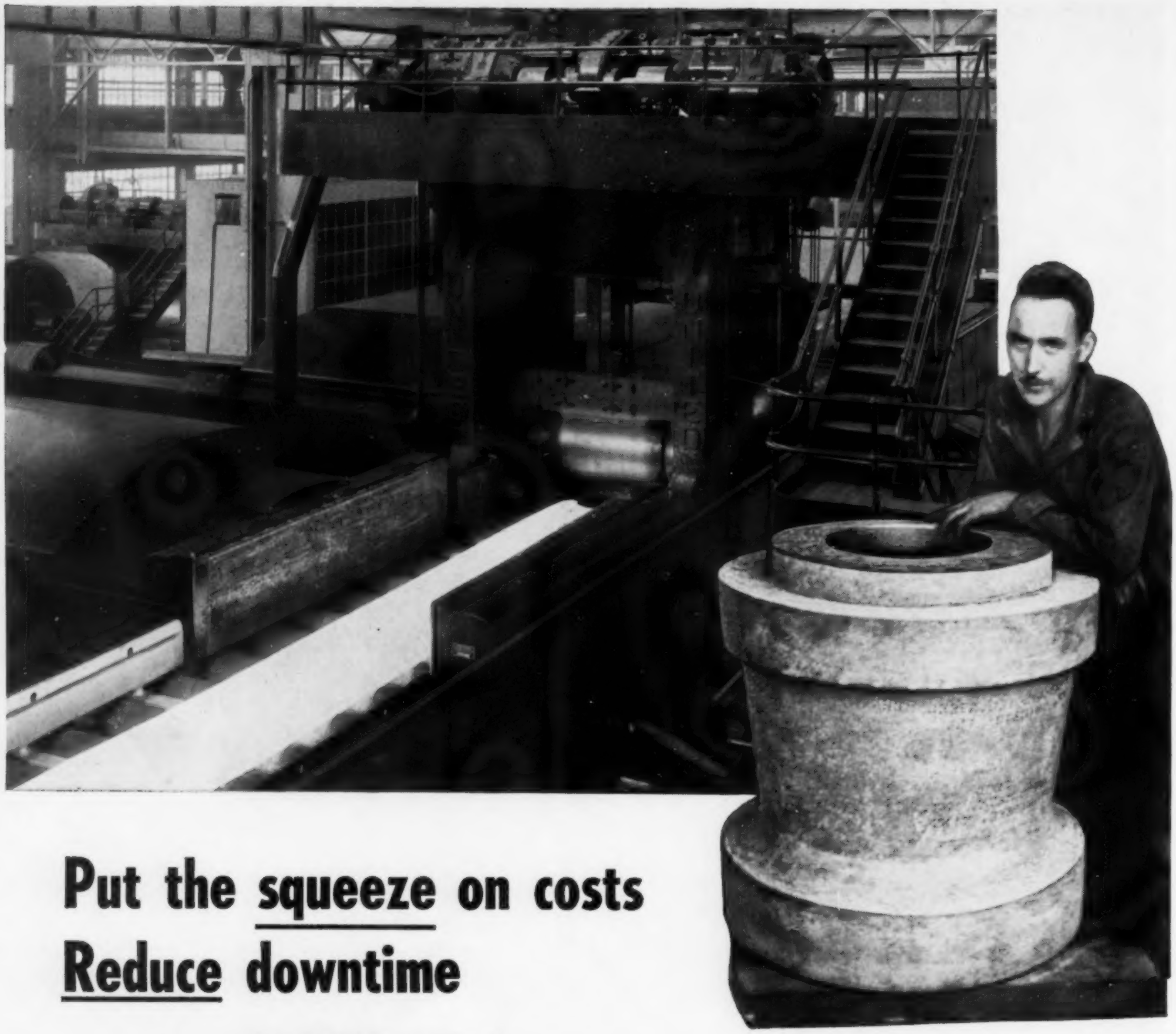

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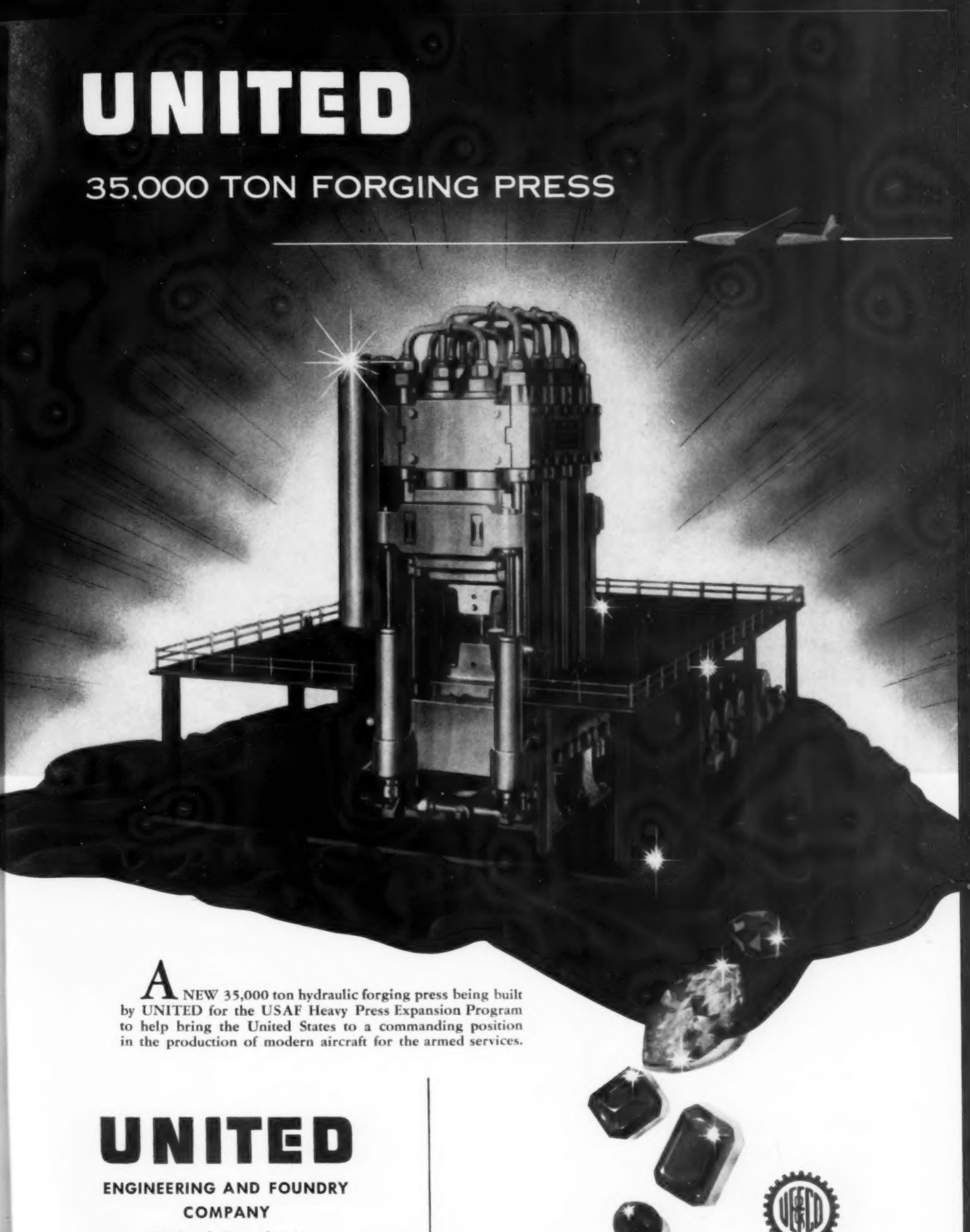

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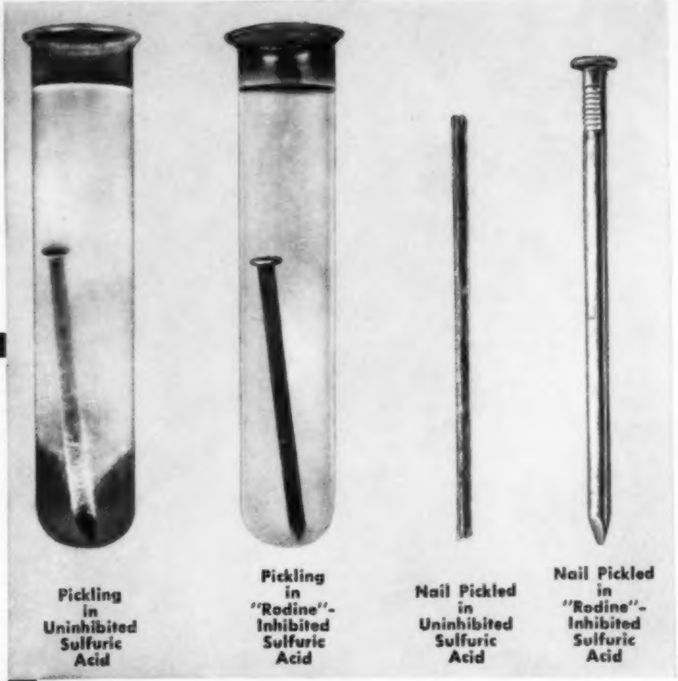
"Rodine" more than pays for itself in savings of acid and metal. More uniform pickling and better pickled surfaces are obtained when "Rodine" is used in acid pickling baths.


Pickling in Uninhibited Sulfuric Acid

Pickling in "Rodine"-Inhibited Sulfuric Acid

Nail Pickled in Uninhibited Sulfuric Acid

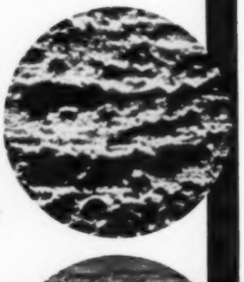
Nail Pickled in "Rodine"-Inhibited Sulfuric Acid

The photographs above illustrate the beneficial effect produced by a small amount of "Rodine" in a pickle bath.

A. Both test tubes contain a 10 per cent by volume solution of sulfuric acid. In the left-hand tube, no further additions have been made to the acid. Notice the gas bubbling off the nail. This is hydrogen, caused by the action of acid on good metal. In the right-hand tube, "Rodine" has been added in an amount equal to 1 per cent by volume of the concentrated acid. Notice the absence of bubbling in this tube. "Rodine" prevents the formation of hydrogen that results from dissolving metal.

B. Both nails after being pickled for the same time. The nail pickled with "Rodine" has lost little weight and has retained its original luster and appearance. The nail pickled without "Rodine" is no longer a nail. "Rodine" prevents the acid from dissolving metal.

This steel surface was pickled in an uninhibited acid bath. Note the deep pits, and that the surface is visibly crystalline.



This surface was pickled exactly like the one above except that "RODINE" was added to the acid solution. Only scale pockets and roll marks are visible; no pitting occurred.

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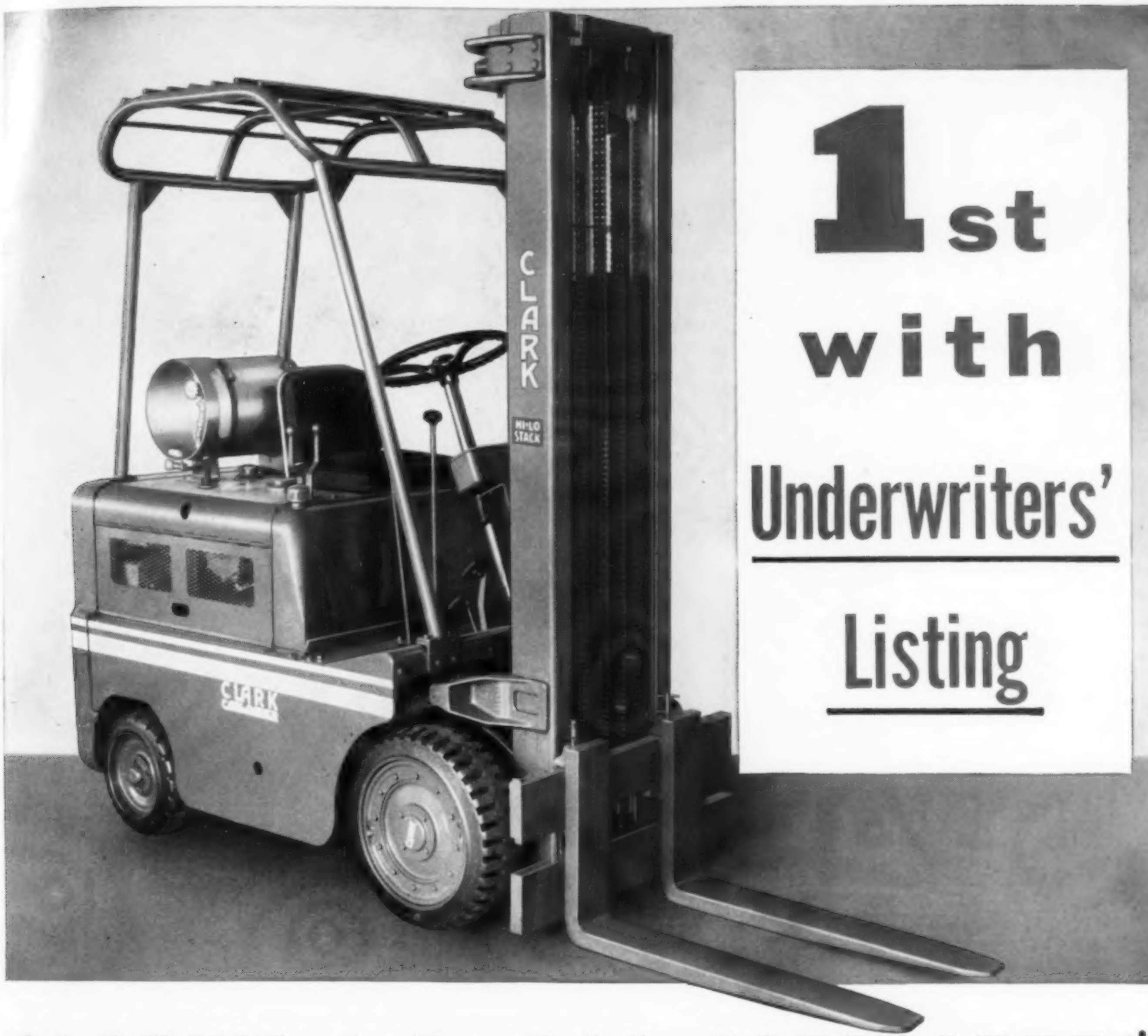

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reduces engine maintenance, eliminates obnoxious exhaust fumes

1. Greatly reduces engine maintenance:

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———eliminates fuel pump and complicated carburetor adjustments.

2. Eliminates obnoxious exhaust fumes:

———L.P.-Gas provides almost perfect combustion, excellent for indoor operations.

3. Provides safe, efficient operation:

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———quickly demountable tank takes 3 minutes to change.

———Stellite valves and seats prevent burning from high flame temperature of L.P. Gas.

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CLARK EQUIPMENT COMPANY
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4930 Manchester Avenue, St. Louis 10, Mo.

Patent Reviews

By MELVIN NORD
Patent Attorney
Detroit, Mich.

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each . . . . patents reviewed cover period March 9, 1954 through March 30, 1954 . . . .

HEATING SCRAP IN OPEN HEARTH FURNACES

▲ In the production of steel in the open hearth furnace, cold scrap metal is charged into the furnace and heating flames are directed into the furnace. During the first stage of the steelmaking operation, the scrap metal is heated and then melted. After the scrap metal has been heated and melted, molten pig iron is charged into the furnace. The bath of molten metal is then refined during the second stage of operation, after which the molten metal — steel — is discharged from the furnace.

The period required for heating the cold scrap metal is quite lengthy, as it takes a long time for the heat from the flames in the upper portion of the furnace to soak down through the pile of scrap metal. Various attempts have been made to reduce the time required to heat the scrap and thereby increase the amount of steel produced per day per furnace. One expedient has been the use of oxygen or oxygen-rich gas as the combustion-supporting gas for the fuel. This use of oxygen increases the temperature of the flames and the temperature in the furnace above the charge, but does not cause the flames or hot gases to penetrate into the pile of scrap. While this increase in temperature reduces the period required for the heat to soak through from the upper surface to the interior of the scrap charge, the period remains quite lengthy and lasts for a number of hours because heat soaks through the scrap charge very slowly.

In U.S. 2,671,724, issued March 9, 1954 to Walter W. Kompart and assigned to National Steel Corp., an improved method is provided of more rapidly heating and melting the scrap charge in an open hearth furnace.

The period required to heat the scrap metal charge in the open hearth furnace is reduced by flooding the interstices between the pieces of scrap metal with oxygen or an oxygen-rich gas. It is believed that the oxygen replaces the gaseous products of combustion or other gases trapped in these interstices so that the interstices are filled with a combustion-supporting gas. Unburned fuel or incompletely burned gases from the flames tend to penetrate the pile of scrap and burn in these interstices to heat the pieces of cold metal more rapidly, particularly the interior pieces of metal. The usual gaseous products of combustion which are trapped in the voids in the scrap pile prevent combustion within the pile and block the travel of the heating flames into the pile so that most of the heat must soak through the large mass of metal. In addition, when the scrap metal has become heated to the ignition temperature and particularly when the scrap metal starts to melt, the oxygen will unite with the hot scrap metal to generated additional heat within the pile. The uniting of the oxygen with combustible gas in the interstices to effect combustion in these voids reduces the first portion of the heating period, during which part of the cold scrap metal is heated to the ignition temperature by generating heat within the pile of scrap metal. This reduces the amount of heat which must soak through the pile of metal from the outer surface. This action plus the heat generated by oxidation of scrap metal after the scrap metal has been heated to the ignition temperature reduces the second portion of the heating period during which the scrap metal is heated above the ignition temperature and melted.

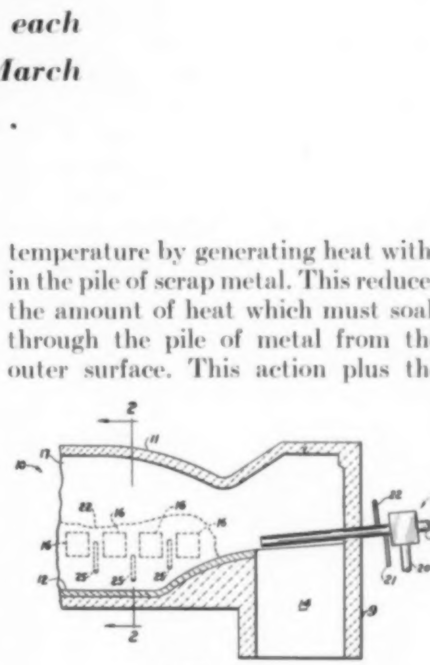

Figure 1

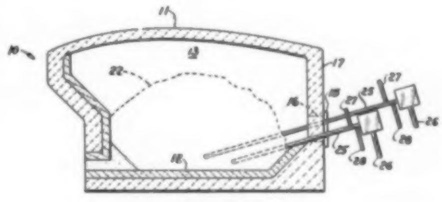

Figure 2

Figure 1 shows a longitudinal section of an open hearth furnace as used in this invention, and Figure 2 is a sectional view taken along line 2-2 of Figure 1.

The open hearth furnace includes a roof 11 and a hearth 12 defining a chamber 13. At one end of the furnace 10, there is a passage 14 communicating with the usual checkers (not shown). A passage (not shown) similar to passage 14 is at the opposite end of the furnace 10. A hot air blast is blown through passage 14 into the furnace and out the other passage. Periodically, the direction of blast flow is reversed as is customary in open hearth practice.

Charge openings 16 are provided in one of the furnace walls 17. A vertically movable door 15 is provided for each opening. The raw materials are charged through openings 16 into the furnace and onto the hearth. An elongated burner 18 extends through wall 9 of the furnace to direct heating flames into the chamber 13. The burner 18 may be connected to a source of fuel, such as gas or oil, through a pipe 19 and a source of air or oxygen-enriched air through pipe 20. Pipes 21 and 22 provide for the flow of cooling water through the burner. The heating flames are directed from the burner into the furnace chamber 13. Combustion-supporting gas from passage 14 supplies the additional gas necessary to burn the fuel. If desirable, all of the combustion-supporting gas, such as air or oxygen-enriched air necessary to burn the fuel, may be provided by the hot blast entering through passage 14, but preferably, at least part of the combustion-supporting gas is mixed with the fuel by the burner.

In operation of the furnace, limestone is first charged into the furnace. Scrap metal, either cold scrap steel or iron, or both, is charged through openings 16 into the furnace in a pile as indicated at 22. The flames from burner 18 slowly heat and then melt the scrap metal during the first stage of the steelmaking operation. After the scrap is melted, molten pig iron may be added. During the second stage of the operation, heating is continued and the metal is refined to form steel having the desired analysis and characteristics. After the refining stage is complete, the molten steel is tapped from the furnace.

A number of pipes 25 extend through the wall 17 into the interior of the pile of scrap 22. Each pipe 25 is connected through a pipe 26 to a source of oxygen-rich gas. The oxygen-rich gas is predominantly oxygen and preferably contains at least 85 per cent by weight of oxygen, although any oxygen-rich gas may be used that contains at least 50 per cent or more by weight of oxygen. The pipes 25 may be provided with connections 27 and 28 for circulating cooling water through jackets to prevent overheating and deterioration or they may be plain steel or iron pipes. If the pipes 25 are not water cooled, the inner ends of the pipes will be slowly consumed, and the pipes should be relatively long so that they can be gradually pushed into the furnace as the inner ends are consumed so as to maintain the inner ends at the desired points in the interior of the pile of scrap.

Directing these streams of oxygen-rich gas into the interior of the pile of scrap floods the interstices between the pieces of scrap metal with the oxygen-rich gas.

The number of points at which oxygen-rich gas is directed into the interior of the pile of scrap metal will depend upon the size of the pile of scrap metal and to a certain extent upon the character of the scrap metal. If the pieces of scrap metal are relatively small, it may at times be desirable to direct oxygen-containing gas into the pile at a greater number of points than when the scrap metal is relatively coarse. If the pile of scrap metal is not too large, the oxygen-rich gas can be injected at one point instead of a number of points.

MANUFACTURE OF STEEL BY BLOWING THE MOLTEN IRON

In the manufacture of steel by blowing the molten iron in a converter, the regulation of the evolution of heat plays a fundamental part. This is especially so when a blast enriched in oxygen is used.

An excessive conversion temperature presents disadvantages such as considerable fixing of nitrogen in the bath. In the Thomas method, a high temperature renders it impossible to effect forced dephosphorization without impairing the quality of the metal. The usual method for maintaining a suitable temperature level consists in regulating the intake of scrap iron. Although this method is economical in the sense that it enables most of the excess heat units to be absorbed by being used for melting the scrap iron, in practice it is incapable of ensuring precise regulation of the temperature. The apparatus used heretofore does not enable continuous intake of scrap iron to be effected, and the cooling action of the scrap iron is subject to considerable delay.

U.S. 2,672,413, issued March 16, 1954 to Jean Daubersy, assigned to Pierre Coheur, describes a method of manufacturing steel by blowing the molten iron and consists of injecting water vapor into the blast. This decomposes endothermically into hydrogen and oxygen, producing a very rapid and efficient cooling.

In the case of blowing with atmospheric air, the operation is effected in such a way as to provide an excess of heat units by keeping the intake of scrap iron a little below its normal rate, that is to say a little below the quantity normally necessary. As soon as the temperature of the bath tends to rise above the level decided upon, cooling is effected by a measured injection of water vapor into the blast. The action is immediate.

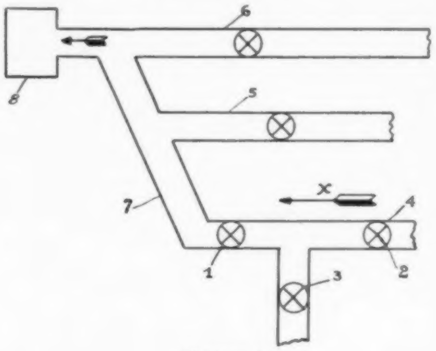

Figure 3

The method is particularly simple, and the cost of the installations required for its application is negligible. The amount of water vapor used is so small that its effect on the cost of the steel is negligible. Regulation of the injection of vapor may be effected according to the operator's estimation of the temperature by sight. It will be more accurate, and can be rendered more or less automatic, if a pyrometer is available for measuring the temperature of the bath or of the flames.

The injection of the vapor is preferably effected by a device with three valves, eliminating all risk of condensation of the vapor from the blast box except at the time of injection. This device, which is illustrated diagrammatically in Figure 3, consists of an arrangement in the form of a T, each of the three branches of which is provided with a valve 1, 2, and 3, for the introduction of superheated steam, which is effected through the duct 4 as indicated. Oxygen and air are passed to the converter 8 through the ducts 5 and 6 respectively.

The device operates as follows:

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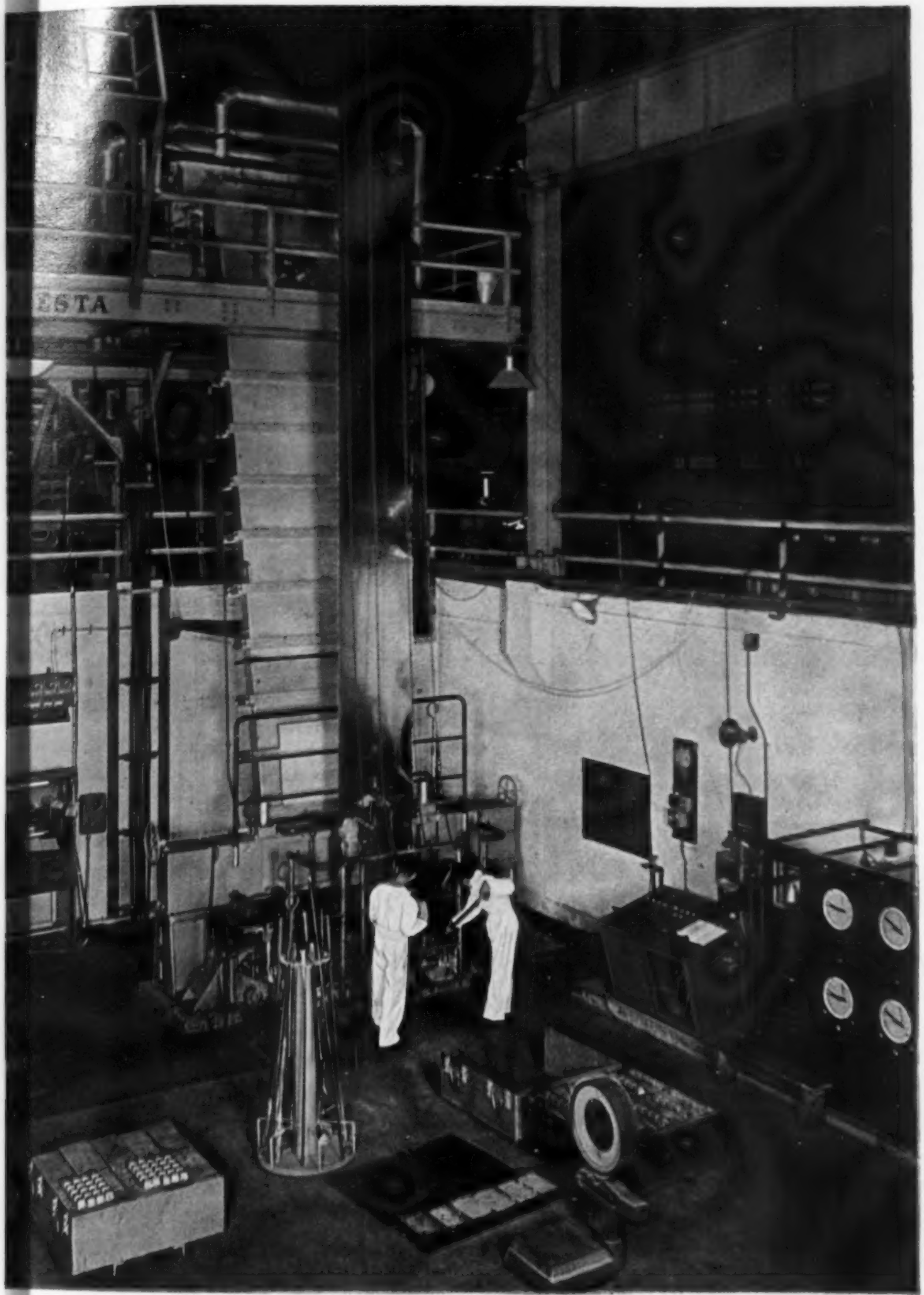

Steel strip passing through a bath of molten zinc on one of the two MESTA 48" CONTINUOUS GALVANIZING LINES

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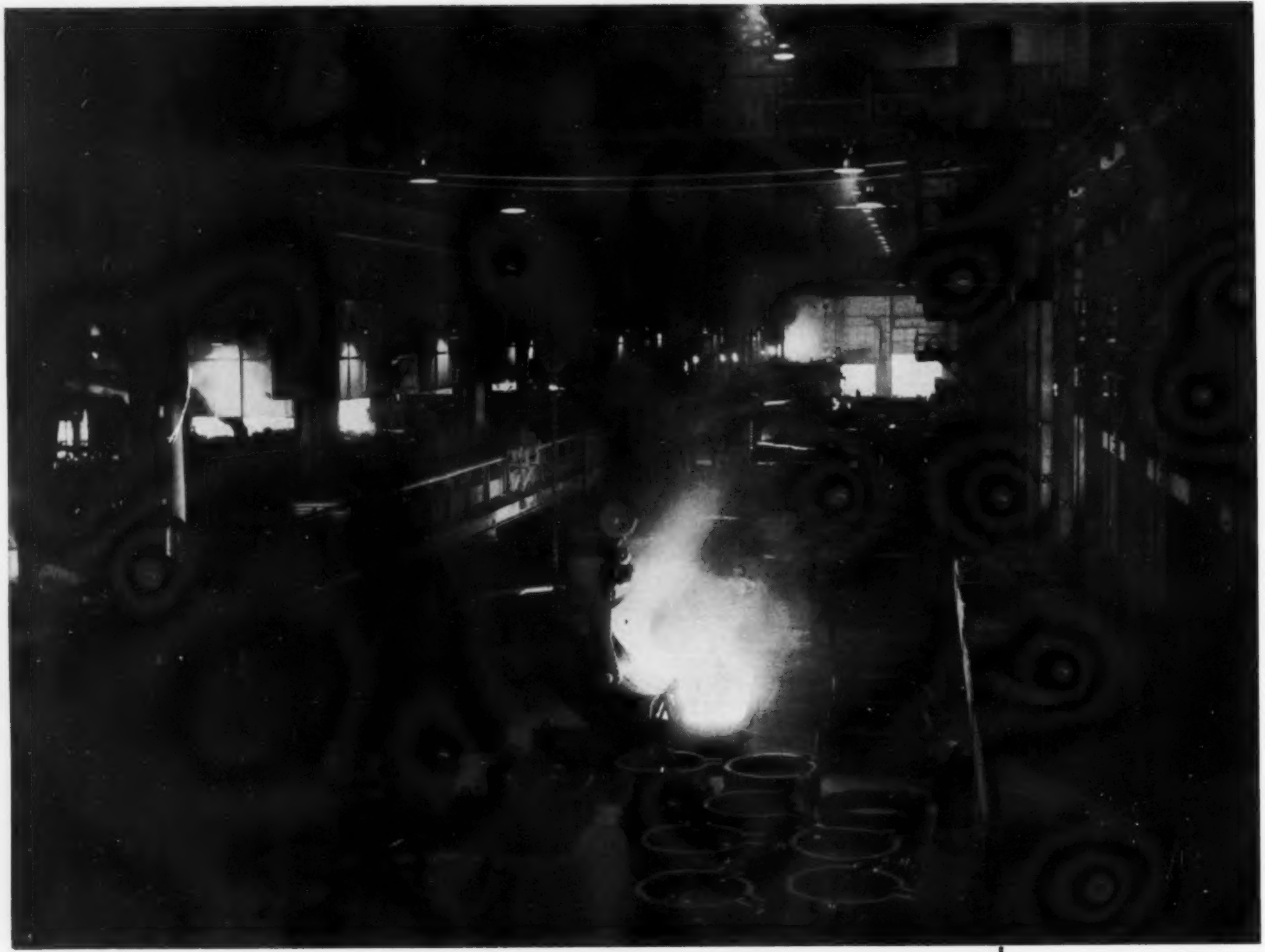

Here's how to eliminate crane downtime due to summer heat

Is your steel mill constantly plagued with that annual problem of increased crane downtime caused by summer heat? With ambient temperatures up to 170 F over soaking pit, open hearth, heat treating and similar areas accentuated by high summer temperatures . . . plus dust, dirt and fumes . . . it's no wonder that crane operators need frequent relief—relief that results in *crane downtime* and *lost production!*

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Before the addition of the steam, valve 1 is closed, valves 2 and 3 are open. Any steam which may have condensed in the duct above the valve 2 is expelled. In order to effect injection, valves 1 and 2 are opened and valve 3 is closed. Immediately after injection, valve 2 is closed and valves 1 and 3 are opened. The blast expels any water vapor which may have been deposited below the valve 1. Valves 1 and 2 are then closed and valve 3 is opened, which removes all possibility of return of steam and deposition of water in the blast boxes during suspension of operation, and consequently removes the danger of explosion.

As regards the time of injection, it has been found that a blast consisting of a mixture of pure oxygen and water vapor may advantageously be used for some time before dephosphorization and up to the final phase of conversion. This mixture may be blown in for a longer or shorter time, and even during the entire duration of the conversion, depending on the importance attached to the diminution of the final nitrogen content of the steel.

COOLING APPARATUS FOR BLAST FURNACE HEARTHS

U.S. 2,673,083, issued March 23, 1954 to Herbert G. MacPherson and Russell D. Westbrook, and assigned to Union Carbide and Carbon Corp., provides a means of cooling the bottom of a carbon-lined blast furnace hearth which will protect against the escape of metal. This is accomplished by placing a layer of graphite between the fire-clay bricks forming the bottom of the hearth and the carbon lining, and providing a cooling medium at the periphery of the graphite. The high thermal conductivity of the graphite enables heat to be conducted away from the center of the hearth rapidly enough to lower the temperature at the carbon-graphite interface below the melting point of the metal.

As shown in Figure 4, the hearth 1 of the furnace consists of sides 3 and a bottom 6 of fire-clay brick. A carbon lining 4 extends across the bottom of the hearth, and carbon bricks 5 line the sides of the hearth. A layer of graphite 7 between the carbon lining 4 and fire-clay bricks 6 conducts the heat transferred from the molten metal to the carbon lining 4 away

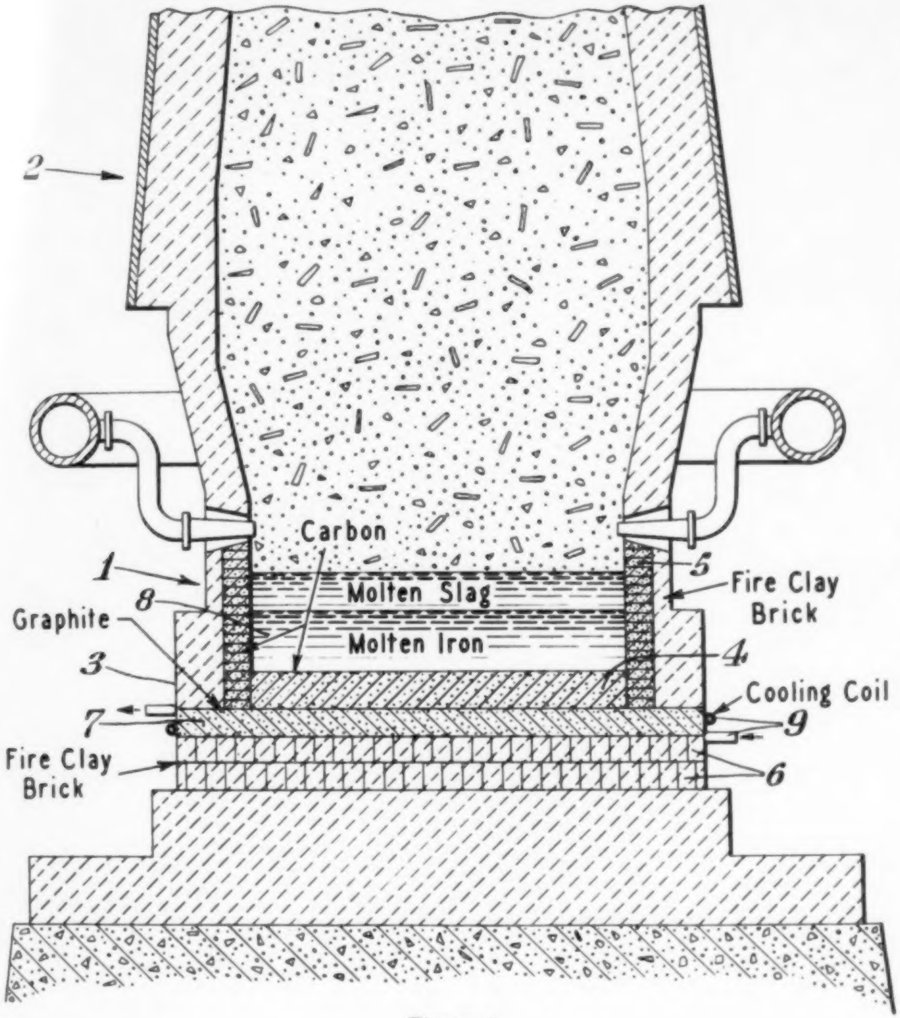

Figure 4

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,671,338	3/ 9/54	Pipe testing machine	Hydropress, Inc.
2,671,339	3/ 9/54	Tube testing machine	Hydropress, Inc.
2,671,651	3/ 9/54	Gas scrubber provided with rotary spraying device and indicator	Koppers Co., Inc.
2,671,654	3/ 9/54	Movable hearth muffle furnace	American Gas Furnace Co.
2,671,658	3/ 9/54	Metal lined cupola	Meehanite Metal Corp.
2,671,726	3/ 9/54	High temperature stainless steel	Armco Steel Corp.
2,672,429	3/16/54	Electrical steel	The Stanley Works
2,672,430	3/16/54	Heat-treating metal objects	Abraham Simons
2,672,661	3/23/54	Rotary-table casting apparatus with water-cooled molds	United States Steel Corp.
2,672,663	3/23/54	Stripping ingots from molds	Republic Steel Corp.
2,673,147	3/23/54	Composition of rolling mill roll	United States Steel Corp.
2,673,166	3/23/54	Treating chromium steel to render it amenable to severe cold-forming operations	Armco Steel Corp.
2,673,363	3/30/54	Ingot mold cleaning device	Theodore A. Repper and Joseph J. Spang
2,673,380	3/30/54	Apparatus for recovering excess molten metal from a continuous casting operation	Campbell, Wyant & Cannon Foundry Co.
2,673,533-4	3/30/54	Replaceable support for refractory lining of open hearth furnace doors	Blaw-Knox Co.
2,673,647	3/30/54	Classification of indurated metalliferrous agglomerates	Oglebay, Norton & Co.
2,673,797	3/30/54	Preventing clogging of the H_2 inlet to a reducing zone in the reduction of ferrous chloride vapor by H_2	Republic Steel Corp.
2,673,820	3/30/54	Treatment of hot metal rods	Morgan Construction Co.
2,673,836	3/30/54	Continuous electrolytic pickling and tin plating of steel strip	United States Steel Corp.

from the center of the hearth to the cooling coils 9 where it is dissipated by the cooling medium in the coils.

HEAT TREATMENT OF STEEL IN A PROTECTIVE ATMOSPHERE

In U.S. 2,673,821, issued March 30, 1954 to Milo J. Stutzman and assigned to Midwest Research Institute, alcohol-water mixtures are used as the protective atmosphere in carburizing operations or in the heat-treatment of steel to prevent oxidation of the surface. Roughly 80-90 per cent of alcohol (ethanol, methanol, or propanol) is used. Decomposition of the carbon, carbon monoxide, and hydrogen occurs at the temperatures used in heat treating processes.

One of the advantages cited for this method is the fact that control of the carbon content of the carburizing atmosphere can be more easily attained than when using water gas or natural gas.

Methods of preparing the atmosphere are shown in figures 5 and 6. In Figure 5 the alcohol and water are mixed in the liquid state and then vaporized, and the vapor mixture is then introduced into the furnace. In Figure 6, the liquids are vaporized separately and introduced separately as vapors into the furnace.

Further details of the conditions of operation are given in the patent specification.

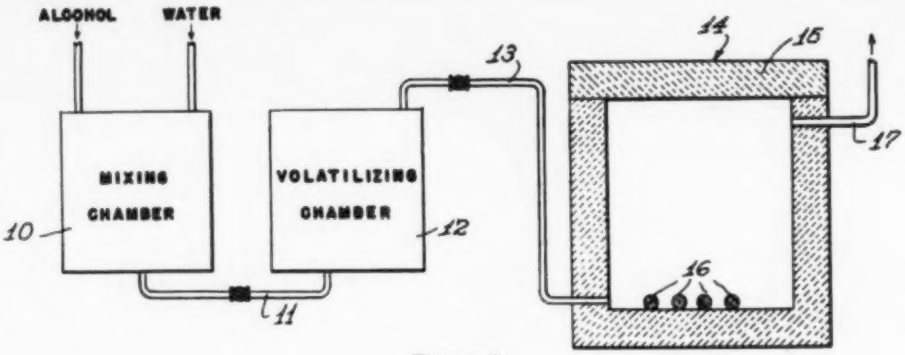

Figure 5

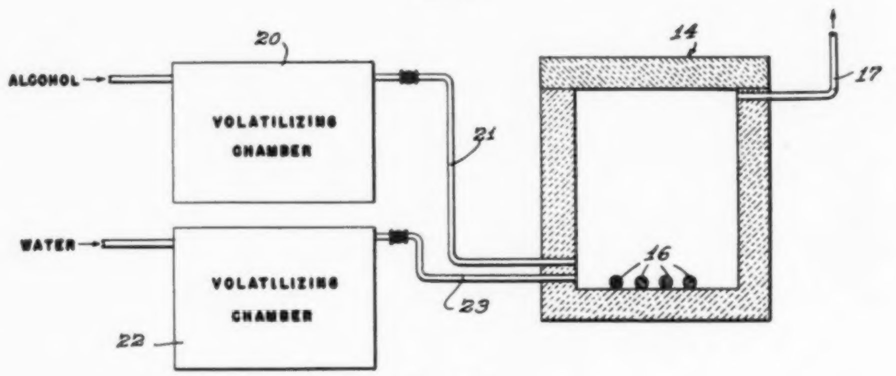

Figure 6

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Testing Anker-Holth Hydraulic Cylinder to be used on a metal stretch forming press. Cylinder on test is 16″ bore, 69½″ stroke, for 3000 psi operating pressure. Tested at 4500 psi.

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● Every Anker-Holth Cylinder . . . large and small . . . is tested at 150% of working pressure with the latest completely-filtered testing equipment. Anker-Holth testing facilities include portable units such as the one shown . . . also stationary equipment for pressures up to 10,000 psi.

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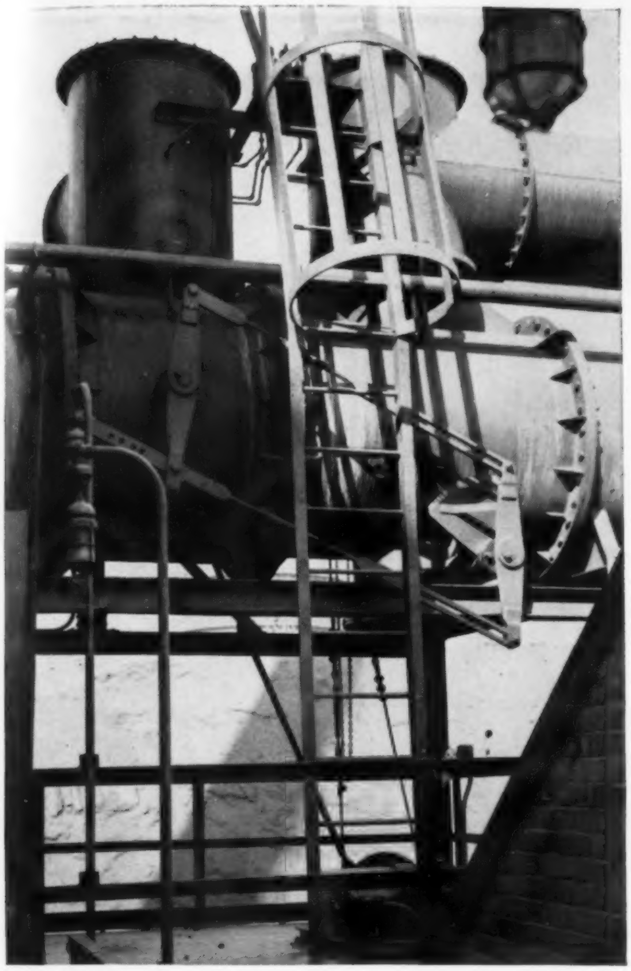
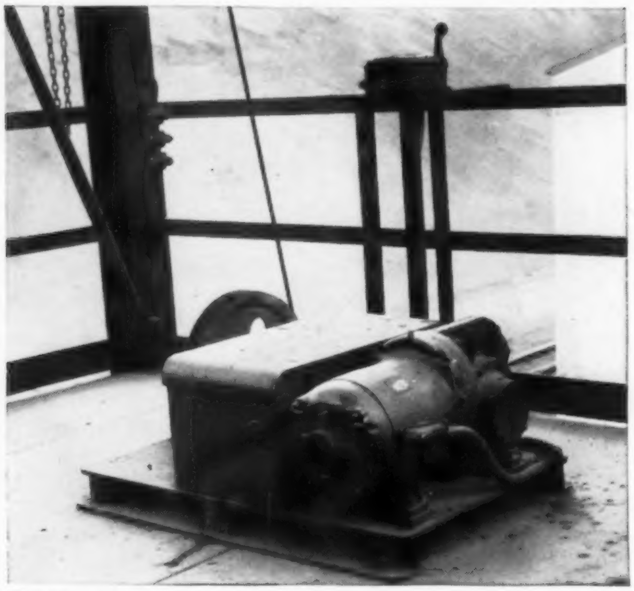


The Complete Assembly



The Operator

Blast Furnace SNORT VALVE may now be MOTOR OPERATED

- ✱ The operator is adaptable to a variety of valve designs.
- ✱ Existing valves may be electrified.
- ✱ Mechanical operation of the valve is preserved intact.
- ✱ Electrical operation is the normal mode. In the event of power failure, reversion to manual operation is automatic.
- ✱ A small master switch supplants the hand wheel.
- ✱ Multiple stations for electrical operation are provided.
- ✱ Quicker response, easier control.

SUCCESSFUL
OPERATION
DEMONSTRATED

KOPPERS

KOPPERS COMPANY, INC.
Freyn Department
Engineering & Construction Division
KOPPERS BUILDING · PITTSBURGH 19 *Associated with* Ashmore, Benson Pease & Co. Ltd., Stockton-on-Tees, ENGLAND
De Lattre & Frouard, Paris, FRANCE

pioneering developments keep WHEELABRATOR® first in blast cleaning

8 Steps to Low Cost Cleaning of Steel Mill Products

Wheelabrator Mechanical Cleaning SAVES Time and Money—Eliminates Acid Handling and Disposal Problems

If you have any of these finishing problems, Wheelabrator Mechanical Cleaning can save time, money and space and improve your operations:

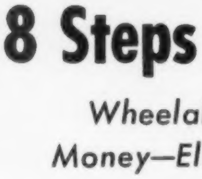
1. Ingot Mold Conditioning
2. Slab and Billet Conditioning
3. Continuous Strip Descaling
4. Sheet Descaling
5. Bar Stock Descaling
6. Wire Rod Descaling
7. Steel Shapes Descaling
8. Etching Mill Rolls

New developments in Airless Wheelabrator blast equipment and abrasives have eliminated all past objections to blast cleaning with an attendant reduction in costs. These have been proved lower than present pickling costs by the many Wheelabrator installations on all types of steel products.

With the Wheelabrator, scale is uniformly and economically removed leaving a surface ideal for cold rolling, cold forming, cold drawing and final finishing such as galvanizing or painting. By eliminating completely or partially the use of acid pickling, the Wheelabrator can equal or better your present costs without any virgin metal loss and with complete recovery of all scale as well as the abrasives used in its removal. Acid disposal problems are eliminated.

These impressive savings are being effected for steel producers and fabricators alike. Rome Cable Corp., for example, selected Wheelabrating for descaling steel strip because it was the only process that would remove surface scale economically and permit the rest of the plant to maintain its high production without requiring a major portion of its plant area.

Write today for complete information on this modern method of steel finishing for your problem.

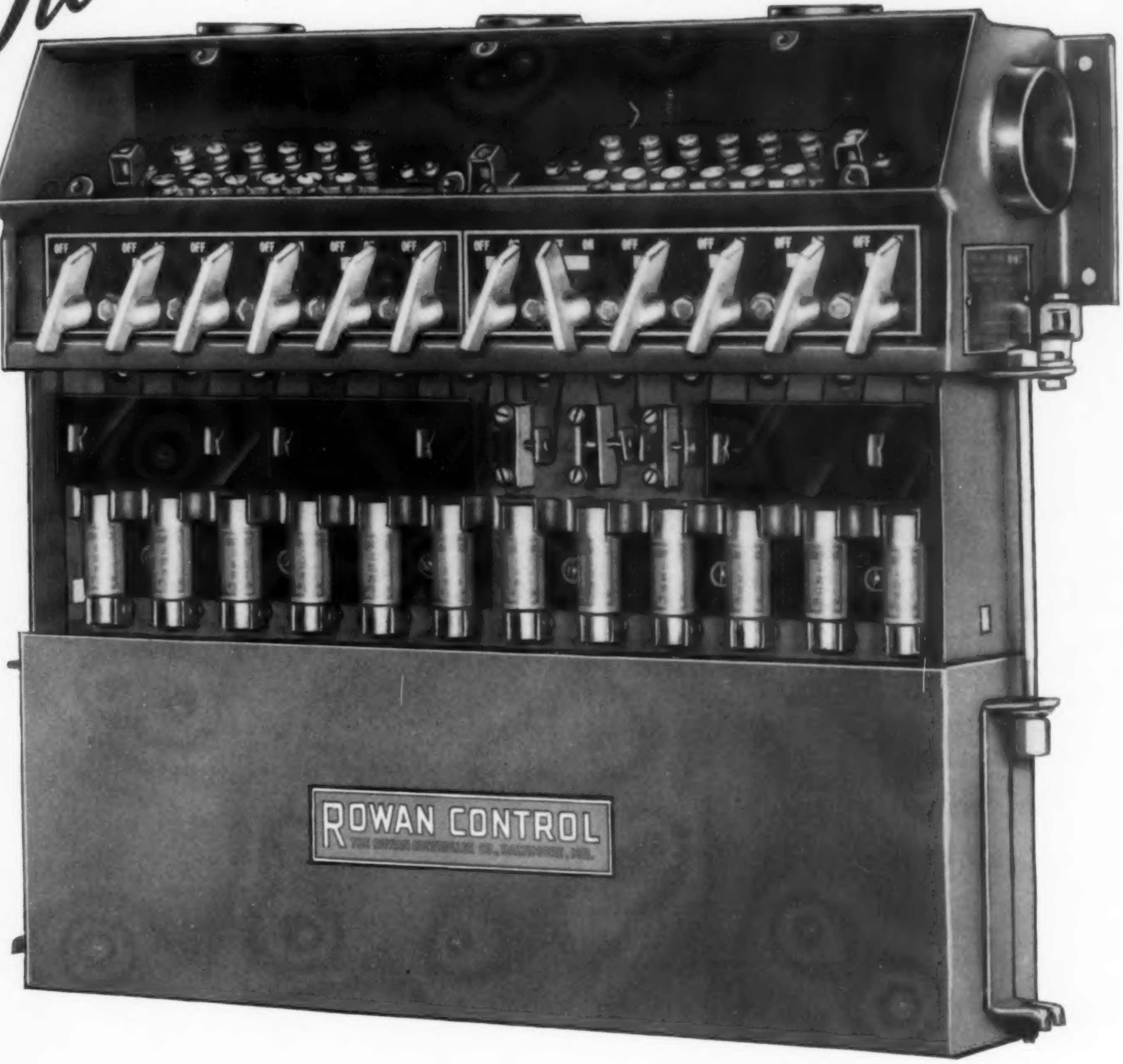


Bulletin 894 describes the descaling of Steel Strip and Bulletin 914 describes the descaling of steel sheets. Send for your copies today.

American
WHEELABRATOR & EQUIPMENT CORP.
396 S. Byrkit St., Mishawaka, Ind.

Wheelabrator®
AIRLESS BLAST
CLEANING

Oil Immersed Series 800-834 LIGHTING SWITCHES



ROWAN Series 800 — 834 Lighting Switches are available in 6- and 12-gang units designed to meet the requirements of NEMA Type XI Enclosures. Internal mechanism is readily accessible for inspection and maintenance. Solderless type, adjustable connectors are provided for line and load connections. Units are equipped with extra heavy, self-aligning, quick make and quick break, renewable contacts. Rowan AIR-SEAL fuses provide time-tested and thoroughly proven short circuit protection.

Complete information is available from Rowan Representatives located in principal cities of the United States.

ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

When you need instrument service . . .

Ever have a tire blow out while you're traveling late at night? If it happens near a service station, you're lucky. But if it's on a lonely road far from town, you've got trouble.

When it comes to service on instruments, you don't need to take chances on being lucky. Because when you have Honeywell instruments, you've always got the comfortable feeling that service is close at hand . . . whenever and wherever you want it . . . from the world's biggest instrument service organization.

Over 110 Service Centers

No matter where you may be, there's a Honeywell service man near you. Offices are located in more than 110 cities of the United States and Canada, near every large production center.

When you run into trouble, just telephone or wire the nearest of these offices. You'll get a service specialist promptly . . . often within a few hours. This quick attention to your needs protects your production schedules, and prevents delays that can cause costly stoppages.

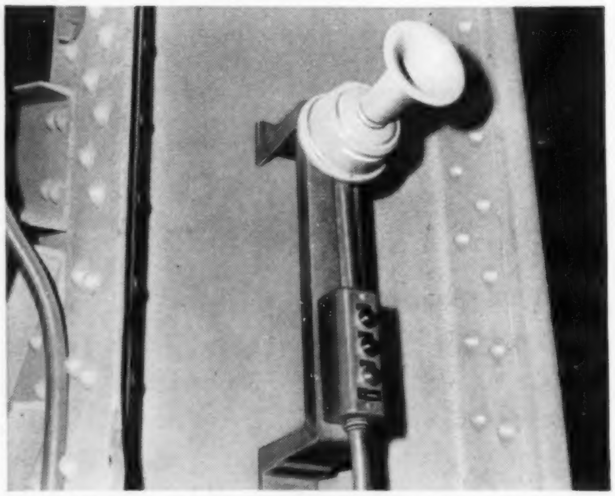
Trained Personnel

Honeywell service men are thoroughly trained for their important responsibilities. In the Honeywell factories, hand-picked men learn both the theory and practice of instrument maintenance. Then they serve an apprenticeship in the field offices, to gain further first-hand experience. You can be sure that the Honeywell man who calls at your plant is a qualified specialist, well versed in the practical art of keeping good instruments in the best condition.

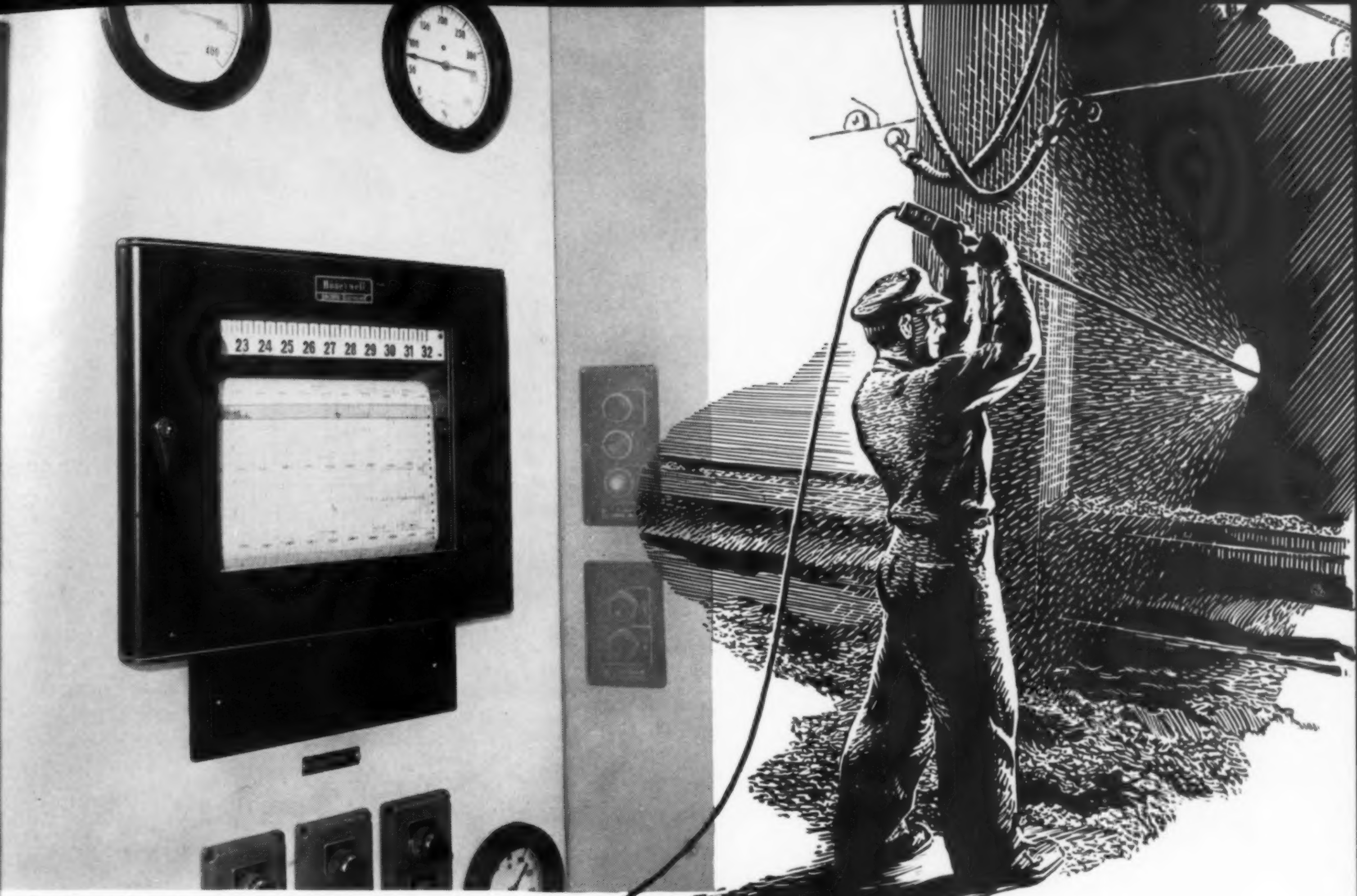
Periodic Service

But why wait for emergencies—when you can prevent them with periodic service. Under a simple contract, a Honeywell man will visit your plant at regular intervals to inspect, clean and adjust your instruments and controls. The plan is economical, and can save you hours of production time. Our nearby branch office will be glad to give full details on Honeywell Periodic Service.

Molten steel temperatures at Fairless Works measured this



Signal lights and horn conveniently located near the furnace guide the operator during measurement . . . eliminate need for several trips across department to read recorder.



ElectroniK instrument on open hearth control panel at Fairless Works records bath temperatures, when the operator inserts an immersion thermocouple into the molten steel.

accurate, convenient way

AT THE Fairless Works of United States Steel . . . as in many other leading steel mills . . . open hearth operators find the *ElectroniK* bath temperature system an ideal way to chart the progress of furnace heats.

Utilizing the accuracy of platinum immersion thermocouples, this system embodies automatic signalling features that make the job of measurement simpler than ever before. The operator is guided by signal lights and a horn located near the furnace . . . doesn't need to depend on shouts or arm signals from an assistant at the control panel. These lights let the operator know when:

1 the thermocouple is correctly connected and the recorder is standardized (green light).
2 the thermocouple is preheating at the wicket hole (flashing orange light).
3 the thermocouple is at safe immersion temperature (steady orange light).
4 true metal temperature is recorded (red light and horn).

This last signalling feature permits substantial savings in thermocouple cost. The operator leaves the couple in the molten steel only long enough to get an accurate measurement. Shortening the time in the bath means that thermocouples last longer.

Your nearby Honeywell sales engineer will be glad to discuss the application of this instrument to your own open hearths or electric furnaces. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO.,
Industrial Division, Wayne and Windrim Avenues,
Philadelphia 44, Pa.

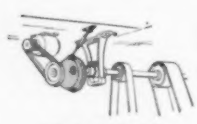
● **REFERENCE DATA: Write for Instrumentation Data Sheet No. 6.4-8a.**

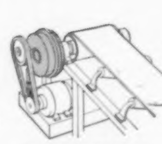
H HONEYWELL

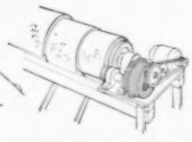
MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS

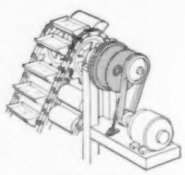
First in Controls

Falk ALL-STEEL Shaft Mounted Drives


LINE SHAFTING


BELT CONVEYOR


GRAVEL CLASSIFIER

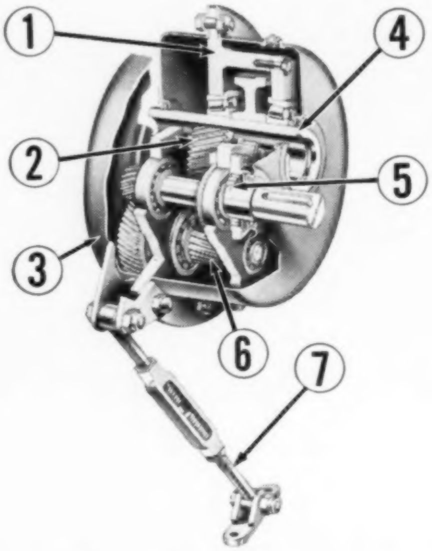

BUCKET ELEVATOR

APPLICATIONS UNLIMITED

The range of applications to which the all-steel Falk Shaft Mounted Drive is ideally suited is so wide that complete listing is impracticable. The sketches above are included only to indicate a few typical installations where considerable speed reduction in limited space is an important advantage.

SIX SIZES

- 1/2 to 30 hp
- Single or double reduction
- Wide output speed range—420 to 10 rpm



These versatile, NEW speed-reducing units

save space, power, material and time

Here is the economical solution to the countless application problems requiring efficient speed reduction in limited space! The new Falk all-steel Shaft Mounted Drive—a modification of the universally-accepted Falk Motoreducer design—embodies many exclusive structural and functional features which add up to better service, longer life and substantial savings.

This rugged, compact drive mounts directly on the driven shaft—a distinct saving in floor space. Its precision Falk helical gearing gives highest mechanical efficiency, with a resultant power saving. No adjustable motor bases or slide rails are required. Installation is simple and rapid—output speeds can be quickly changed; thus time is saved...Write to Department 247 for engineering bulletin, including selection and dimension details.

FALK "In-Built" Factors... that give maximum efficiency, convenience and dependability

1. **All-steel Frame,** with more than double the rigidity of iron, supports all rotating elements.
2. **Precision Helical Gears,** designed and machined by Falk, rated to AGMA standards.
3. **Pressed Steel Housings,** whose sole function is to keep oil in, dirt out; easily removed for gear inspection without dismounting unit.
4. **Through Hollow Shaft** with counter bore provides for easiest installation or removal from driven machine shaft extensions.
5. **Backstop** can be furnished with the unit or added later for positive prevention of reverse rotation.
6. **Positive Lubrication,** continuous direct dip of revolving elements at all speeds.
7. **Tie Rod** and turnbuckle serve as anchor and facilitate V-belt or chain adjustment.

THE FALK CORPORATION, Milwaukee 8, Wisconsin

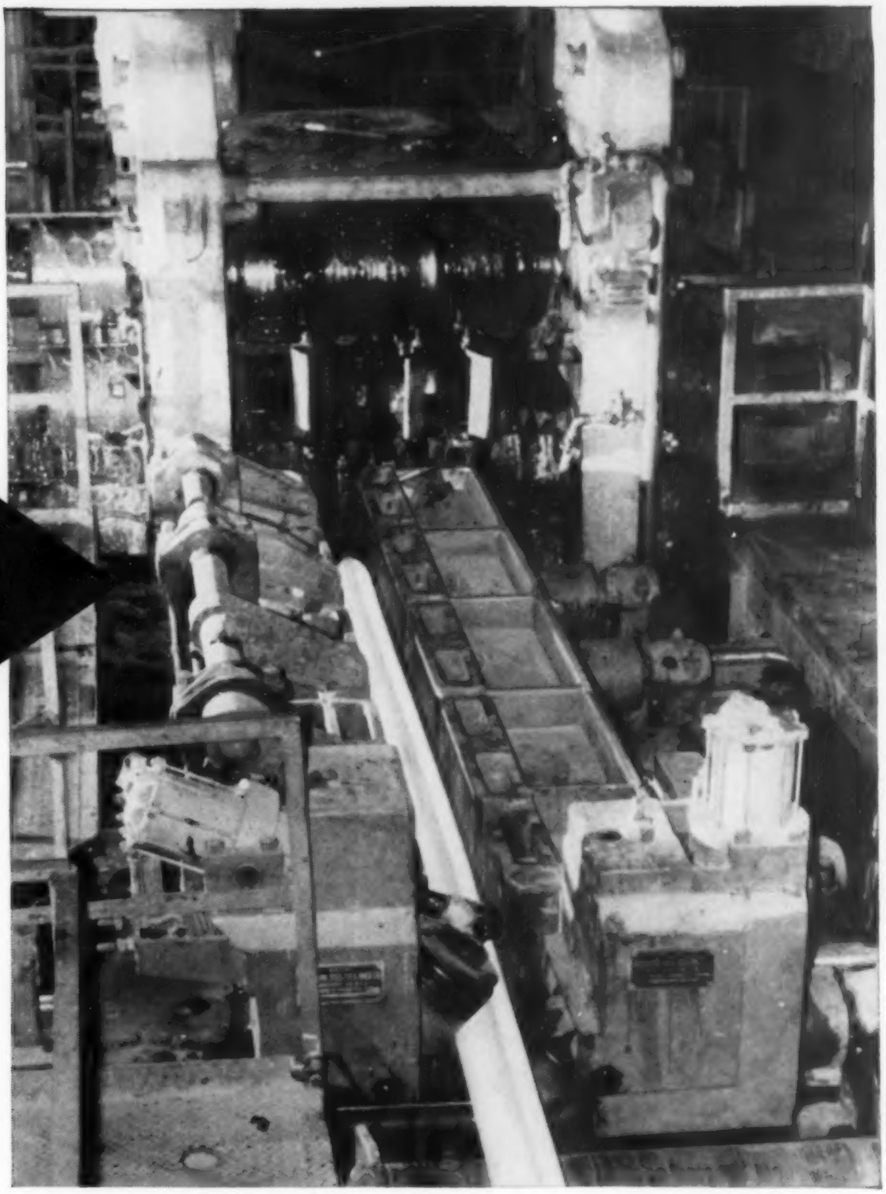
MANUFACTURERS OF

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

FALK

...a good name in industry

for maximum tonnage



BIRDSBORO / STEEL MILL MACHINERY

• This 3-high mill is equipped with a tilting table, side guard manipulators, finger lift for turning square and rectangular shapes, and auxiliary manipulator for turning diamonds and squares. It is just one example of how Birdsboro engineers can help you boost your tonnage, and reduce labor costs. For a single piece of machinery or a complete new plant, it always pays to call on Birdsboro.

Designers and Builders of:

- STEEL MILL MACHINERY
- HYDRAULIC PRESSES
- CRUSHING MACHINERY
- SPECIAL MACHINERY
- STEEL CASTINGS
- Weldments "CAST-WELD" Design
- ROLLS: Steel, Alloy Iron, Alloy Steel

MM-33-54

BIRDSBORO

BIRDSBORO STEEL FOUNDRY & MACHINE CO., BIRDSBORO, PENNA. Offices in Birdsboro, Pa. and Pittsburgh, Pa.

Maintenance Costs Go Down

with NATIONAL CARBON BRUSHES for

TRADE-MARK

MAIN DRIVE, MILL-TYPE AND GENERAL-PURPOSE MOTORS

ENGINEERS:

Fewer items do a better job when you select "National" brushes—simple, fast, accurate brush specification for *you!*

MAINTENANCE MEN:

Long life, low friction, minimum commutator maintenance — an outstanding cost-record for *you!*

PURCHASING AGENTS:

The brushes you want, *when* you want them, from stock or catalog listings — you get a higher degree of in-plant-standardization, lower inventory, fewer costly, short-run items!

STOREKEEPERS:

Stack 'em high, wide and handsome with these durable, easy-to-identify "National" brush cartons—good housekeeping, faster check-outs for *your* department!

How good is really good brush performance? Use "National" brushes and see!

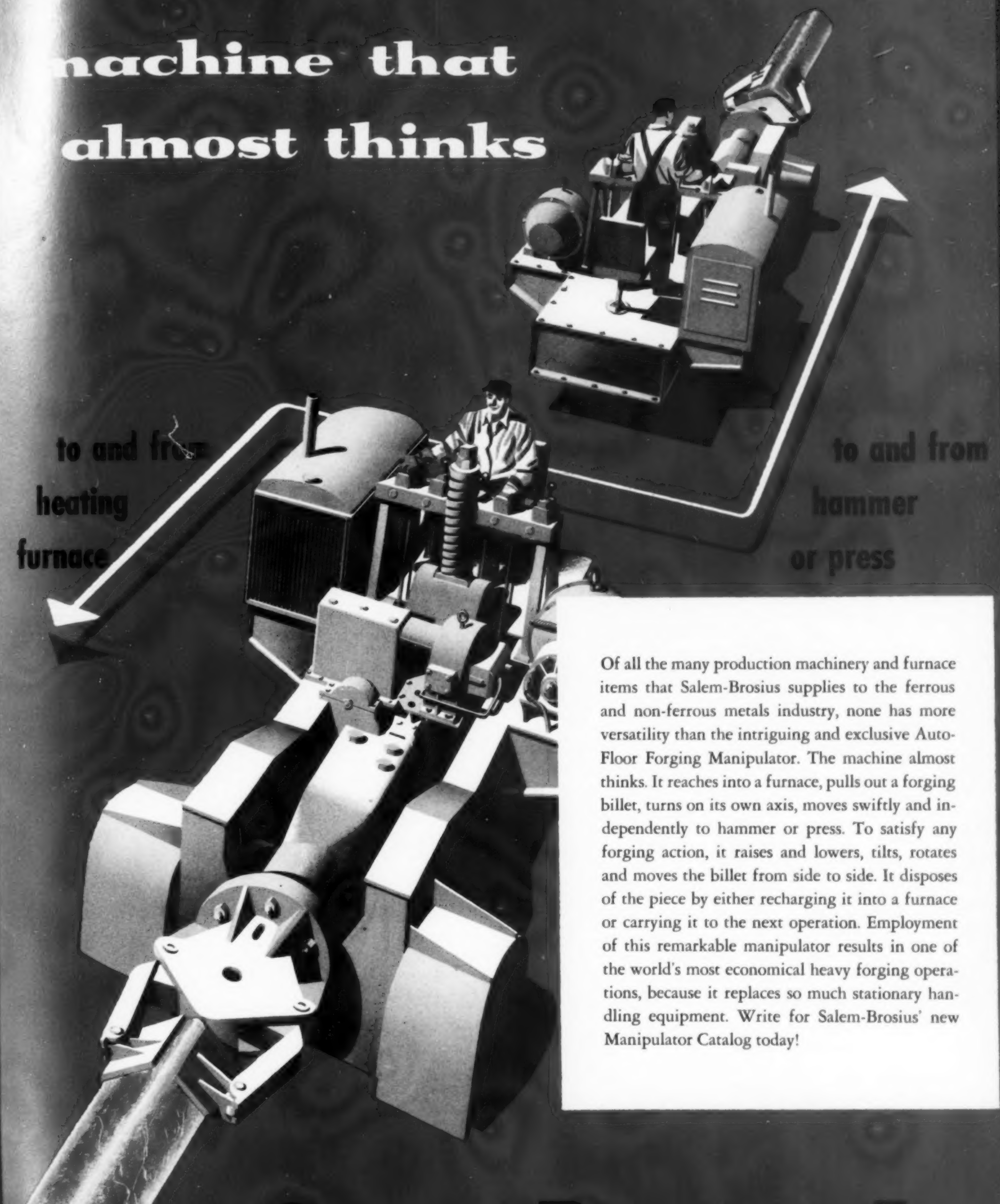
The term "National", the Three Pyramids Device and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.
District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco
IN CANADA: Union Carbide Canada Limited, Toronto

NATIONAL STANDARDIZED BRUSHES

BETTER—PRODUCT—PACKAGE—PRICE—FASTER

nachine that almost thinks



Of all the many production machinery and furnace items that Salem-Brosius supplies to the ferrous and non-ferrous metals industry, none has more versatility than the intriguing and exclusive Auto-Floor Forging Manipulator. The machine almost thinks. It reaches into a furnace, pulls out a forging billet, turns on its own axis, moves swiftly and independently to hammer or press. To satisfy any forging action, it raises and lowers, tilts, rotates and moves the billet from side to side. It disposes of the piece by either recharging it into a furnace or carrying it to the next operation. Employment of this remarkable manipulator results in one of the world's most economical heavy forging operations, because it replaces so much stationary handling equipment. Write for Salem-Brosius' new Manipulator Catalog today!

SALEM-BROSIUS, INC.

EXECUTIVE OFFICES: 248 FOURTH AVENUE, PITTSBURGH 22, PA.
GENERAL OFFICES: 714 SOUTH BROADWAY, SALEM, OHIO

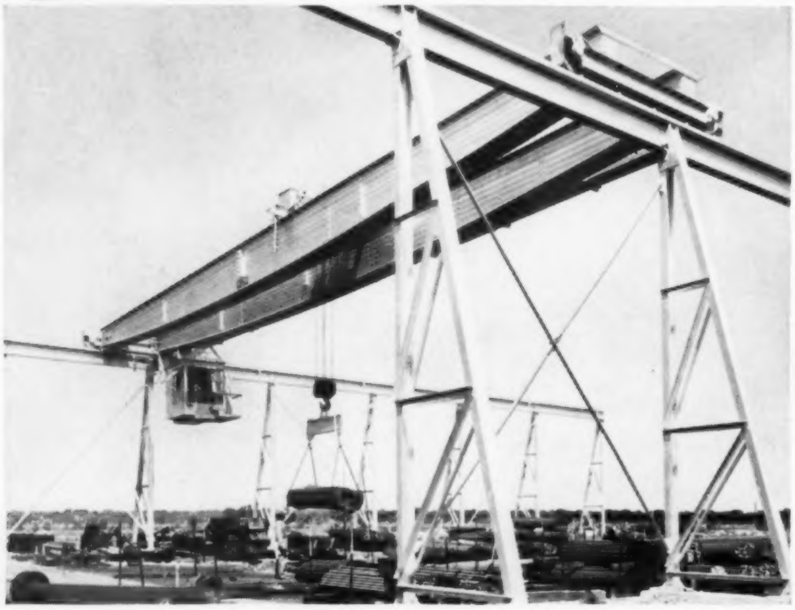
Wagner®
CRANE-BRIDGE BRAKES
. . . the choice of leaders in industry

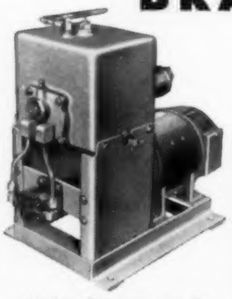
Stop Overhead Cranes

EASILY—SAFELY—WITH

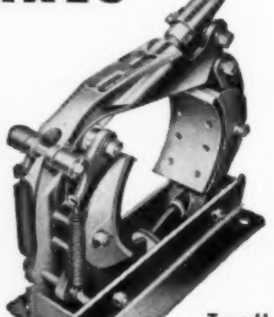
Wagner

Powered Hydraulic CRANE BRIDGE BRAKES





Hydraulic power unit driven by totally-enclosed motor



Type H or HM2 Brake Unit

Hydraulic braking systems for overhead traveling cranes—pioneered by Wagner—have become an industry standard.

Now, Wagner offers *Powered* Hydraulic Crane Braking for safer, more efficient operation where frequent starts and stops are necessary . . . where close spotting is required . . . where heavy equipment is involved . . . and for any application where exceptional ease of brake operation is desired.

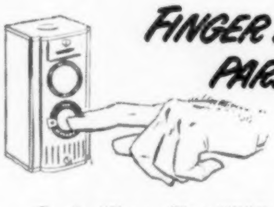
Wagner Powered Braking Systems save you money because they lengthen the life of your equipment. Operators don't drag brakes and unnecessarily wear wheels and lining—cranes can be controlled without bridge motor plugging with its resultant damage to both motor and gears.

These Power Units can be added to your present Wagner Hydraulic System. Only six weeks are required to fill the average order. Bulletin IU-36 gives full details—write for your copy today.

TIP TOE BRAKING

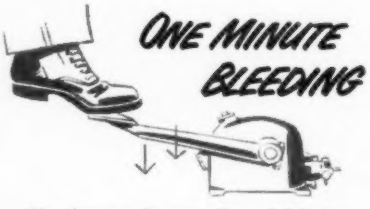
With Wagner Powered Brakes, tons of weight can be stopped by the touch of a toe. Loads can be spotted accurately—production can be stepped up—several brakes can be operated from one pedal.

FINGER TIP PARKING



On the Wagner Type HM-2 System, a button operated spring-set brake permits safe parking, easily controlled by the crane operator. The parking brake also sets automatically, to bring the crane to a gradual stop in case of power failure.

ONE MINUTE BLEEDING



The Wagner Remote Control Bleeder permits the operator to keep the hydraulic system filled with air-free fluid for maximum efficiency. Bleeding the system is a one man job—the operator need only press a push button and pump the foot pedal several times.

Wagner Electric Corporation
EST. WE 1891

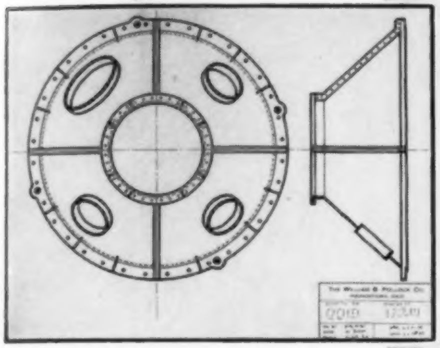
WAGNER ELECTRIC CORPORATION
6483 PLYMOUTH AVE., ST. LOUIS 14, MO., U.S.A.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

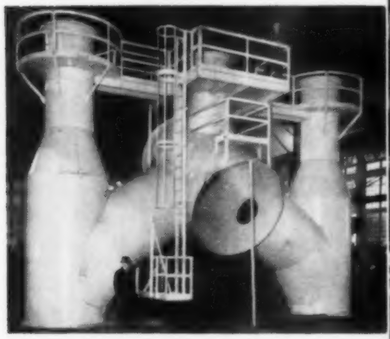
- ELECTRIC MOTORS
- TRANSFORMERS
- INDUSTRIAL BRAKES
- AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

154-2

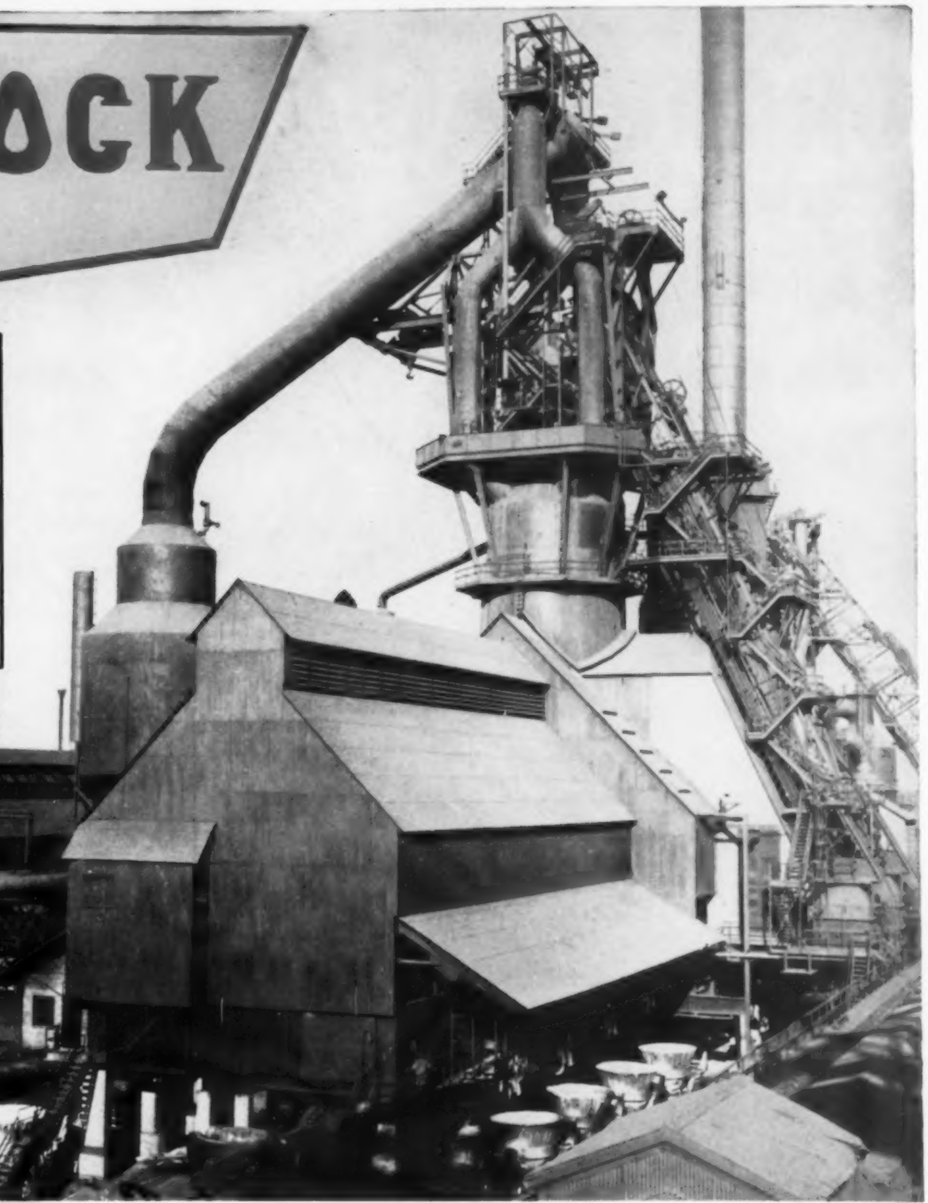
POLLOCK



ENGINEERING



SHOP FABRICATION



FIELD ERECTION

Correlating the skills of Pollock engineering, fabrication and field erection to specific operational requirements of The Youngstown Sheet & Tube Company are evidenced in this blast furnace. In addition to furnishing the steel work for this blast furnace, Pollock designed and built auxiliary equipment, including the hot metal ladle cars and cinder cars shown in the above picture. The experience which the Pollock Company has gathered in over eighty-five years is available to you in planning your new projects.

Blast furnace STEEL WORK

POLLOCK

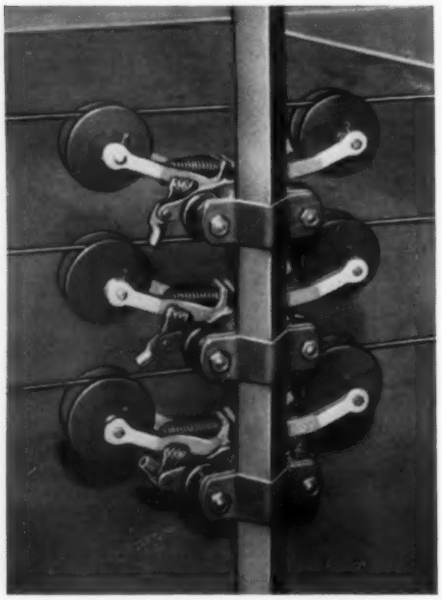
THE WILLIAM B. POLLOCK COMPANY
YOUNGSTOWN · OHIO
STEEL PLATE CONSTRUCTION · ENGINEERS · FABRICATORS · ERECTORS

BLAST FURNACES · HOT METAL CARS AND LADLES · CINDER AND SLAG CARS · INGOT MOULD CARS · CHARGING BOX CARS · WELDED OPEN HEARTH LADLES

GRAPHITAR®

current collector wheels for overhead electric cranes

GRAPHITAR current collector wheels increase operating efficiency, reduce maintenance costs and give longer service in this difficult application



Excellent conductors of electricity, GRAPHITAR (carbon-graphite) collector wheels for overhead electric cranes provide numerous advantages over ordinary metal wheels. GRAPHITAR is self-lubricating, making bushings unnecessary and completely eliminating the need for greasing. GRAPHITAR minimizes pitting, arcing and burning, thus putting an end to dead spots in the line that reduce operating efficiency. GRAPHITAR wears exceptionally well and will give longer service than ordinary metal wheels. GRAPHITAR is chemically inert and will not be affected by fumes, heat, cold, rain or snow. For complete information, write us today

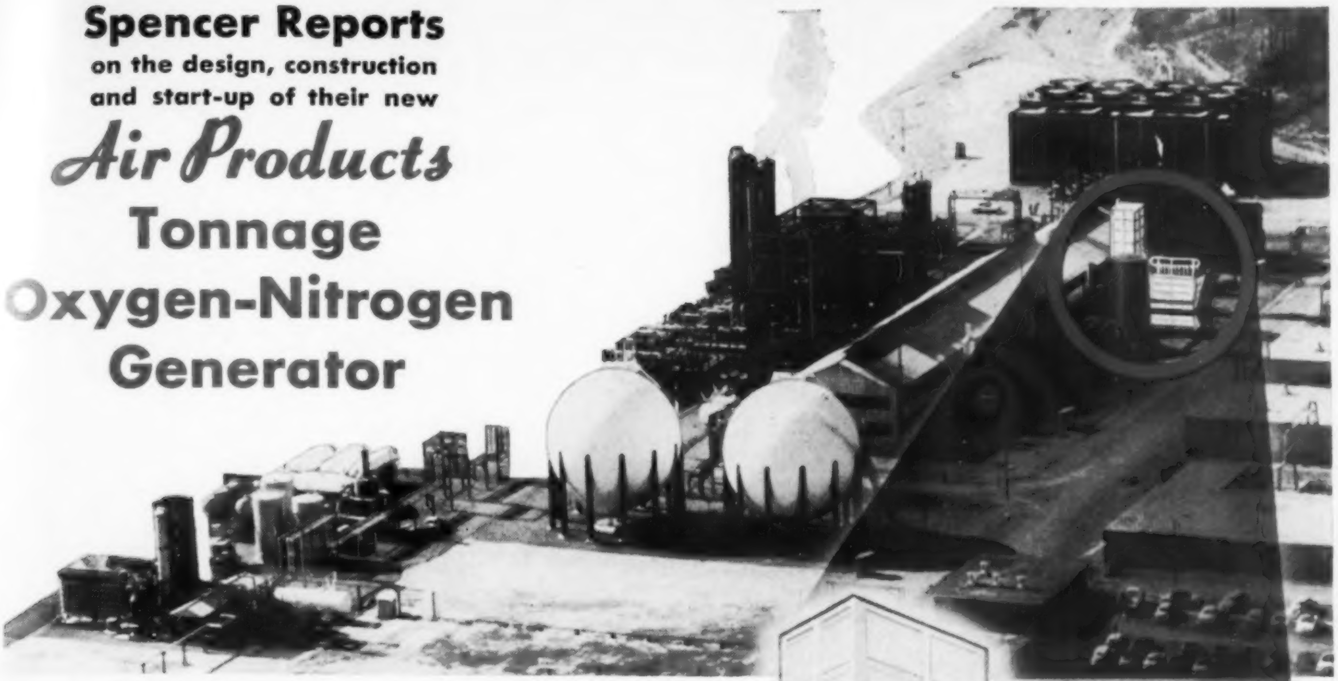
OUR 100th YEAR

184

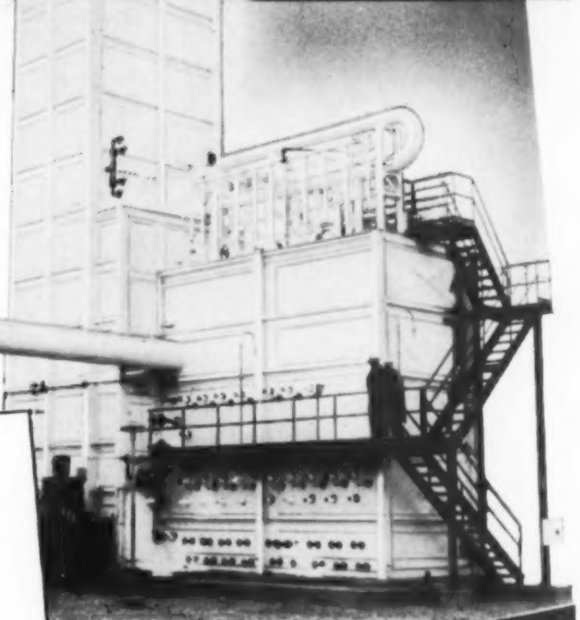
THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

Spencer Reports
on the design, construction and start-up of their new
Air Products Tonnage Oxygen-Nitrogen Generator



• Spencer Chemical Company's New Ammonia Plant at Vicksburg, Miss.



Spencer Chemical Company
DWIGHT BUILDING
Kansas City 5, Missouri

Mr. Leonard Pool, President
Air Products, Incorporated
P. O. Box 538
Allentown, Pennsylvania

Dear Mr. Pool:

"...I want to express for the entire Spencer Company our appreciation for the strong team of technical men that you have sent down to assist with the erection of the Air Plant and put it through its initial paces. They are not only technical experts, but have exhibited a fine attitude towards working together with our men."

"...It is particularly gratifying to us to see that the expanders and liquid oxygen pumps are both performing excellently."

Very truly yours,

R F Brown

R. F. Brown
General Works Manager

"...I should like again to compliment you and your organization on the fine manner in which you cooperated with all of our Spencer people during the construction and start-up of the Vicksburg Unit. To my knowledge, it was a relationship which left little or nothing to be desired."

Very truly yours,

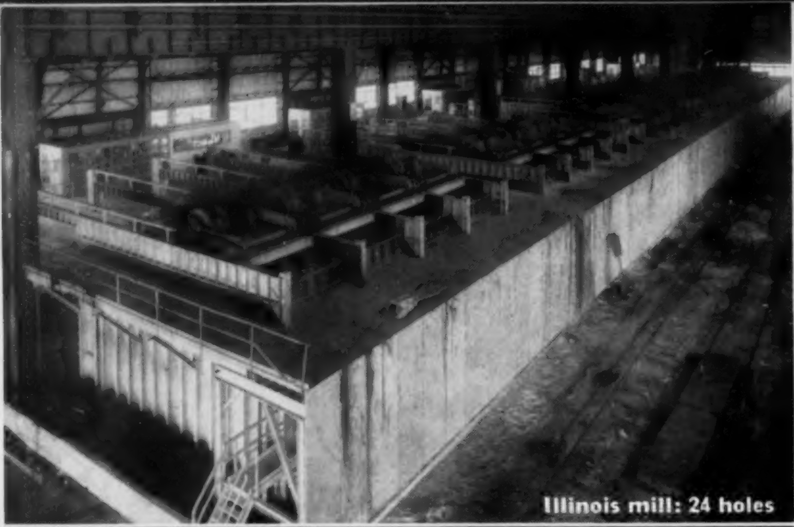
B M Kern

B. M. Kern
Chief Engineer

For this kind of service from inquiry to start-up . . . and on through the years of operation . . . entrust your low-temperature processing work to *Air Products.* If your project calls for a tonnage or high-purity oxygen and/or nitrogen generator . . . large or small hydrogen purification plant . . . a plant for separation of coke oven gas, refinery fluids . . . call us in. We can provide cost data, process design, apparatus design and manufacture . . . whatever you require. ***Air Products, Incorporated, Dept. P Box 538, Allentown, Pa.***

Send for 36-page brochure, "Low-Temperature Processing"

Air Products
INCORPORATED
Specialists in Low-Temperature Processing

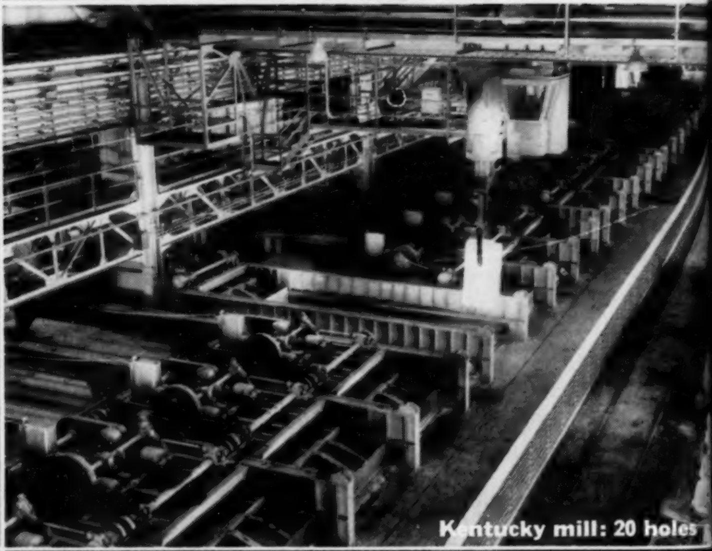

Illinois mill: 24 holes

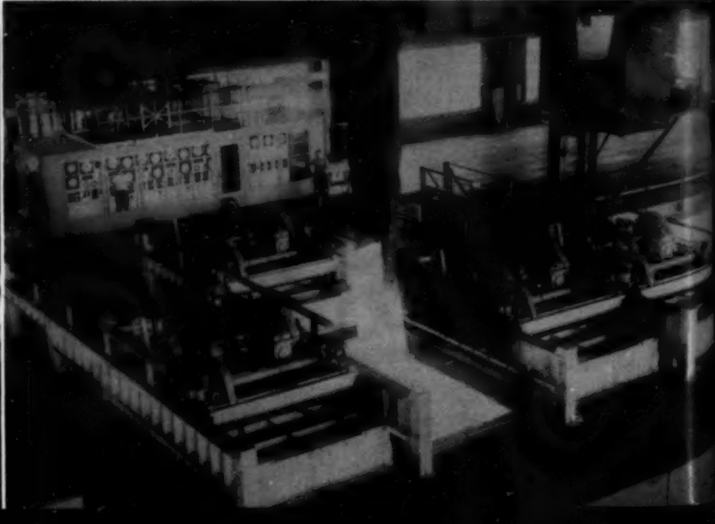
Illinois mill: 12 holes

271 PITS

In the steel industry's current modernization program, Surface Combustion has installed 271 one-way fired soaking pits, with a capacity of 20 million tons a year. That's nearly 90% of the pits built since World War II. We believe there is a simple explanation for these facts: Surface Combustion is known for the quality of engineering that developed the jet pump recuperative system and for the experience gained in almost 50 years of working with steelmakers. 'Surface' means equipment that performs up to the customer's requirements, or better.

SURFACE COMBUSTION CORP.
Toledo 1, Ohio


Kentucky mill: 20 holes



holes

0 holes

New York mill: 16 holes

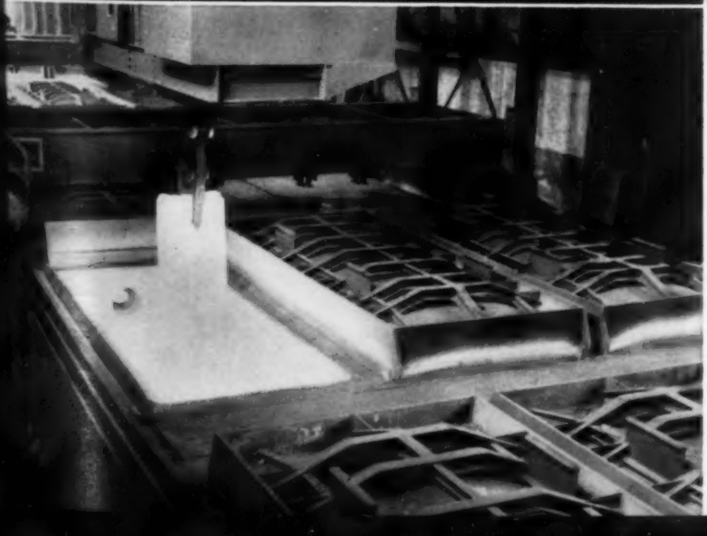
Pennsylvania mill: 16 holes

Pennsylvania mill: 30 holes

IN 7 YEARS

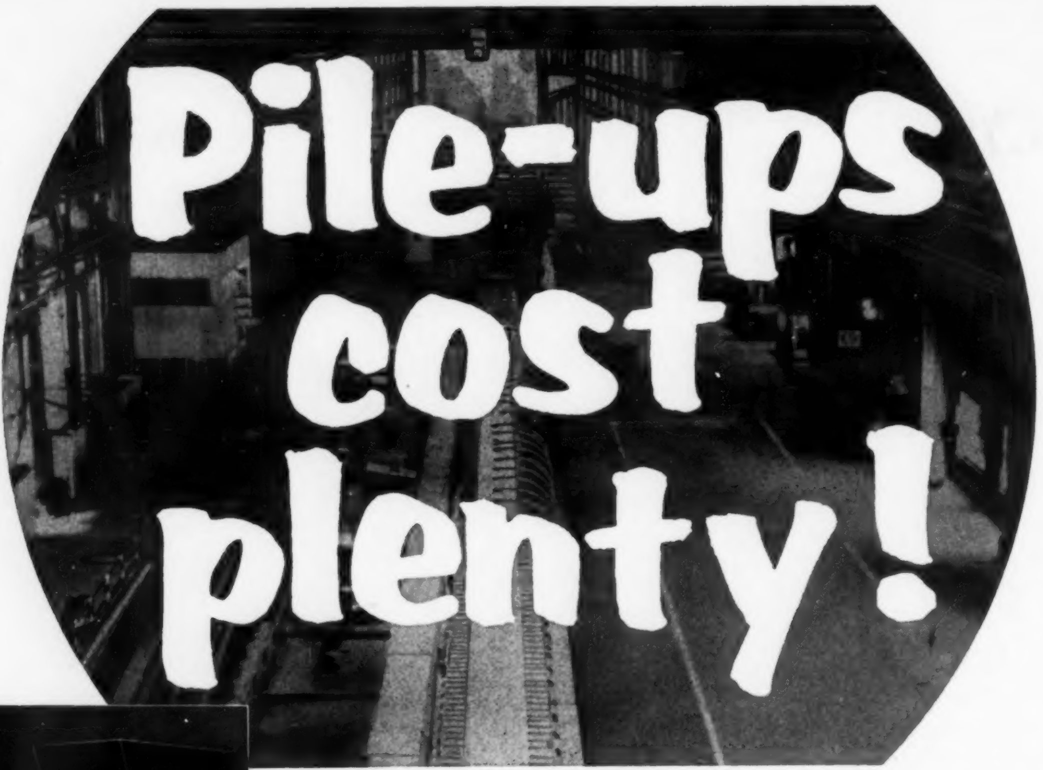
20 MILLION TONS/YR.

Mexican mill: 6 holes



Surface

STEEL MILL FURNACES



Pile-ups cost plenty!

. . . So they prevent them at Gary with RCA Industrial TV

One pile-up at United States Steel Corporation's Gary Sheet and Tin Mill could mean as much as 15 minutes lost production time, or approximately 120 tons of steel! So, at their 80-inch strip mill they installed RCA Industrial TV. This mill holds the world's record for production of hot strip.

A TV screen on the control pulpit (see photo) permits the operator to maintain control of the movement of the hot strip. Television affords the opportunity to keep constant watch and to spot threats of pile-ups before damage occurs. In this way control of strip shape is improved, costly delays are minimized . . . hundreds of tons of steel are saved. The RCA Industrial TV system has been in continuous operation for over a year.

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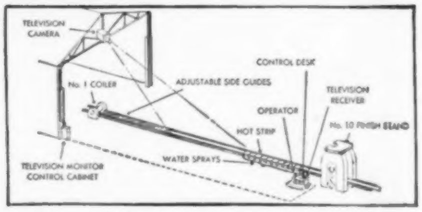

Diagram showing TV camera mounting

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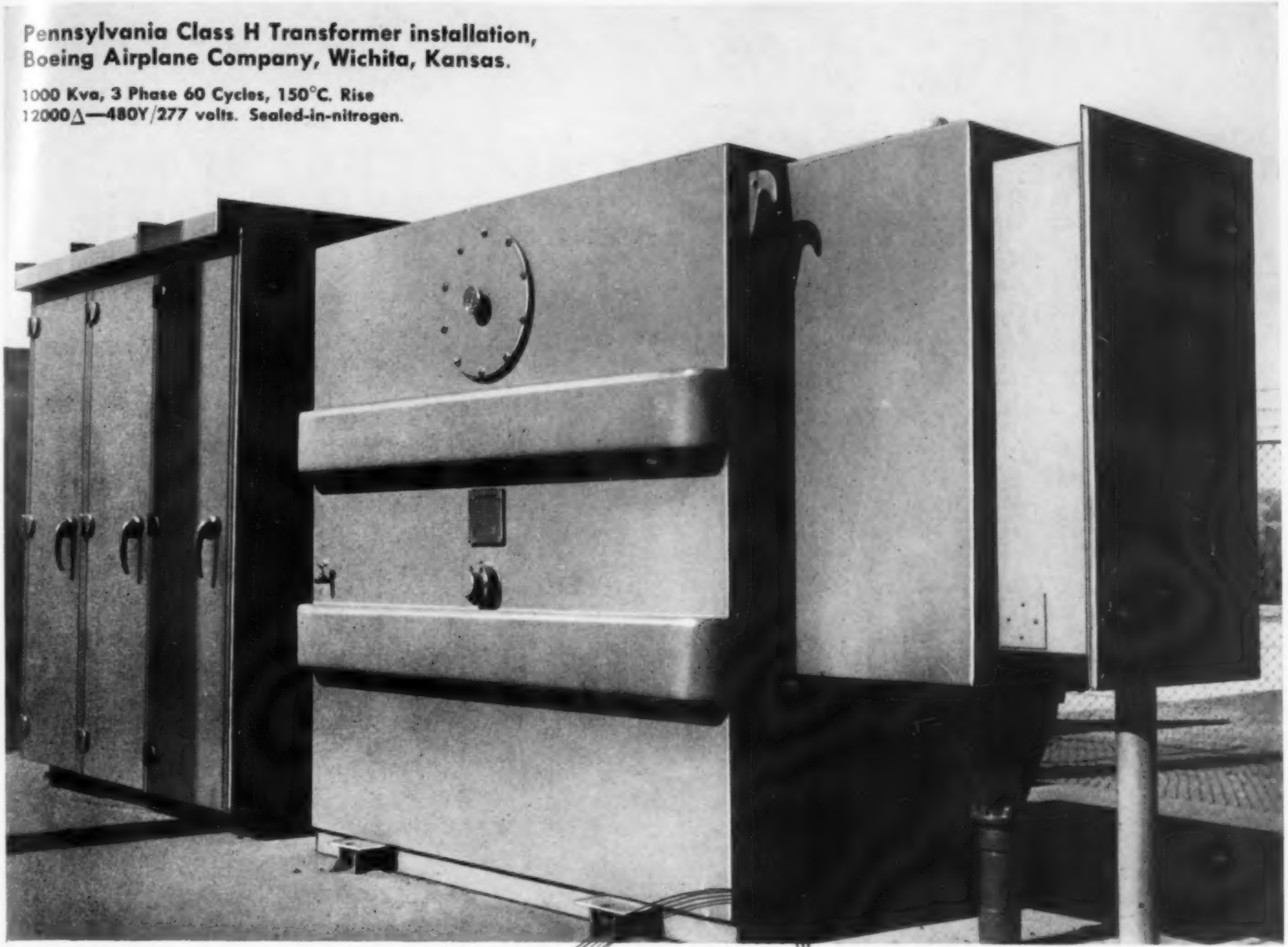

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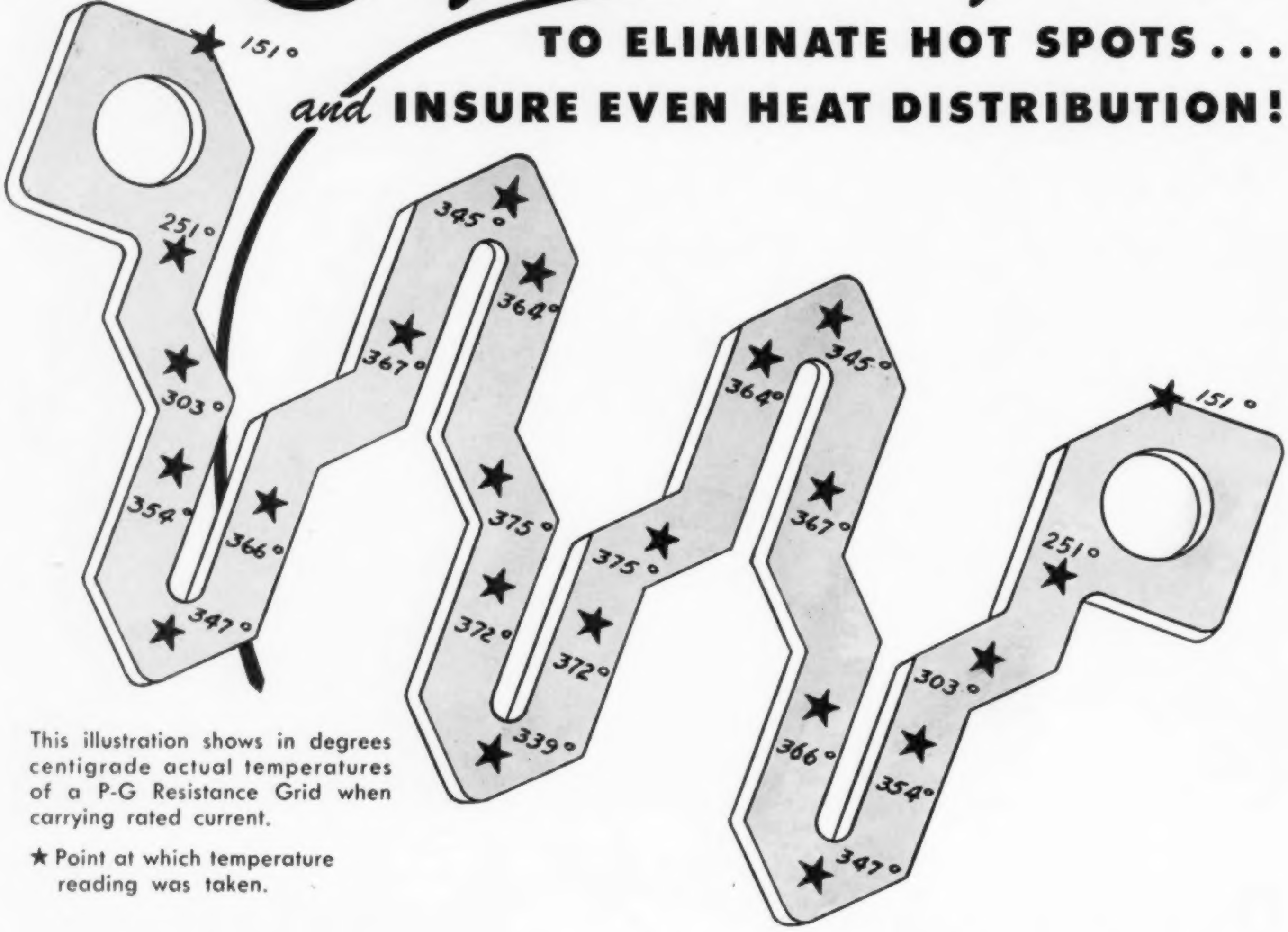

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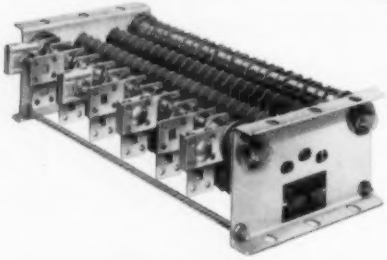

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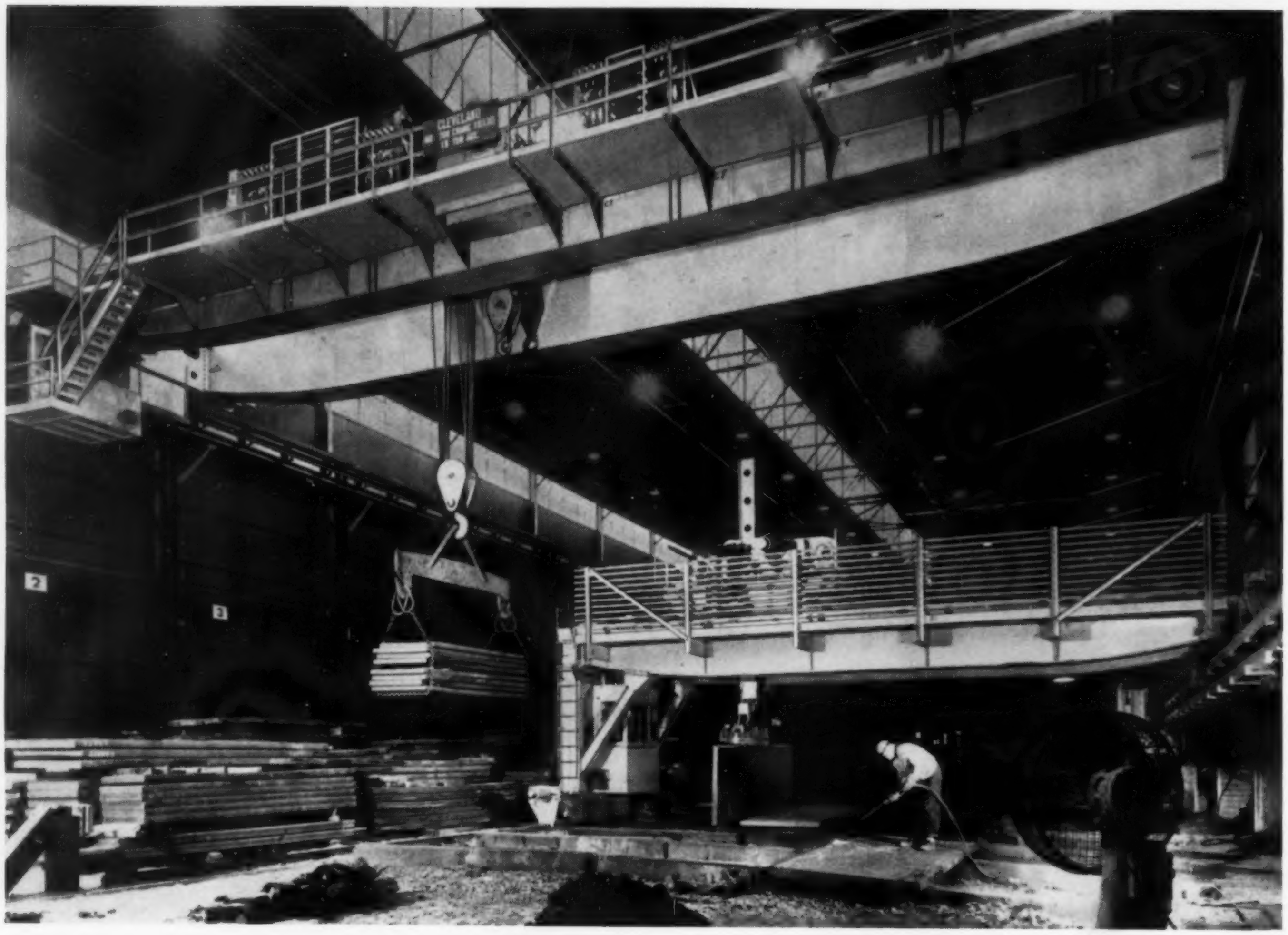

15 ton, 40'-0" span Cleveland scarfing gantry operating underneath one of two 40 ton, 90'-0" span overhead traveling Cleveland Cranes in the Slab Conditioning Department. The overhead cranes haul the heavy slabs to and from the scarfing bed area.

SCARFING GANTRY with RAM-TYPE HOIST

OF INTEREST to mill men is the Cleveland single-leg scarfing gantry crane in the Conditioning Department of the Pittsburgh Steel Co., Allenport, Pa. This has a ram-type hoist which eliminates the usual swinging of loads of conventional cable or rope-type hoists. Equipped with two magnets on the ram, the gantry crane handles the heavy slabs in the area it serves and turns them over from one side to the other, enabling the scarfers to clean and prepare them quickly, ready for rolling.

The crane is unusual in that no line shafting or other mechanical connections between the bridge drives at both ends of the crane is employed. Each end truck is individually motor driven. This method of driving the bridge eliminates many bearings and considerable gearing and is an important factor in reducing maintenance to a minimum.

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

5031 EAST 289th ST.
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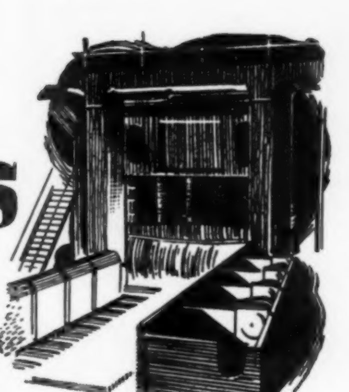
Crops *and* Shorts



THE new contract negotiated with the United Steel Workers calls for a wage increase of five cents an hour plus improved pension and insurance benefits which will cost another four or five cents an hour. It is estimated that this will increase the cost of steel by three or four dollars per ton.

The agreement has received wide acclaim in the general press because it means peace in the steel industry for another year. But in almost every case, the praise was accompanied by hopes that the steel industry would absorb the increase and not raise steel prices. This reminds us of the verse:

I wish you all the luck there is,
And all your heart's desire,
And all the money in the world
That I do not require.

For ten years or more, rising living costs have been the basis for wage increases, with the wages even out-stripping the cost of living. But with the leveling off of living costs, emphasis was shifted to productivity and unions generally were quick to claim not only the fruits of productivity, but the basket as well. Ignored were the people who make increased productivity possible by investing the $11,000 necessary to put plants and modern equipment back of each production worker.

We've heard a lot of people say "This is no time for a strike." Nor is it the time for raising wages. A wage increase in the steel industry was not justified at this time, either by living costs or by productivity. It must be recognized only as a bribe to maintain industrial peace.

We think this might have been the year to hold the line. It's got to happen some time unless we are going to accept a creeping inflation that will help no one in the long run. As bad as a strike is, it might be only the pain of having a tooth fixed rather than losing the tooth.

However, since wages were increased, we believe that the three-dollar per ton price increase is justified. The man who put up that $11,000 is entitled to a fair return on his investment.

▲

A correspondent tells us about a plant that uses a live skunk as an award in its clean-up program. The skunk is given to the dirtiest department, which must keep it for a month. If the skunk should die while in the keeping of a department, that department must find a new skunk.

P.S. — The skunk is deodorized.

SPEAKING of strikes, Pittsburgh trolley and bus operators, who recently returned to work after a five-week strike, gained three cents per hour by striking. The increase will pay back their five weeks' lost wages in about six years and four months.

▲

WE understand that some towns are posting new traffic signs reading: Watch out for school children — especially if they're driving cars.

▲

SUSTAINED activity in the construction field has been a godsend to the drooping steel production. Thus far in 1954, construction and contractors' products have used just about as much steel as they did in the same period last year.

Out of April's direct shipment of finished steel, which totaled 5,287,972 net tons, these items received 1,017,700 tons.

▲

JOSEPH L. BLOCK, president of Inland Steel Co., has predicted a rise in the use of steel within the next 25 years to a possible total of 200,000,000 tons per year, twice the production of any year prior to 1951. He believes the growth will come from a growing population, a rising standard of living, and new uses for steel.

▲

AN opportunist is someone who, finding himself in hot water, decides he may as well have a bath anyway.

▲

J. E. WALTERS, of Rutgers University, told the American Society of Mechanical Engineers that 40 per cent of all industrial executives are engineers, and that 60 per cent of all engineers are engaged in administrative functions 20 years after graduation.

▲

ONE of our disillusioned friends says that any man who gives up when he is right is either weak and spineless or married.

▲

ALTHOUGH a comparative youngster in the industrial family of the United States, Wean Engineering Co., cutting its twenty-fifth birthday cake this year, parallels to a striking degree, one of the greatest developments in the history of steel.

When the Wean organization was founded in 1929, there were six wide strip mills in the country rolling about 1,740,000 tons a year. Today there are 39 strip mills rolling some 29,000,000 tons a year.

Although its activities are not confined to this field alone, Wean Engineering and its associated companies contributed extensively to this progress with developments in continuous processing equipment for these mills.

May they have many more happy anniversaries!

▲

THIS year's engineering graduates of Illinois Institute of Technology are averaging $363 per month salary, about the same as last year. Starting salaries averaged $193 in 1944 and $282 in 1949.

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The ELECTRIC SERVICE

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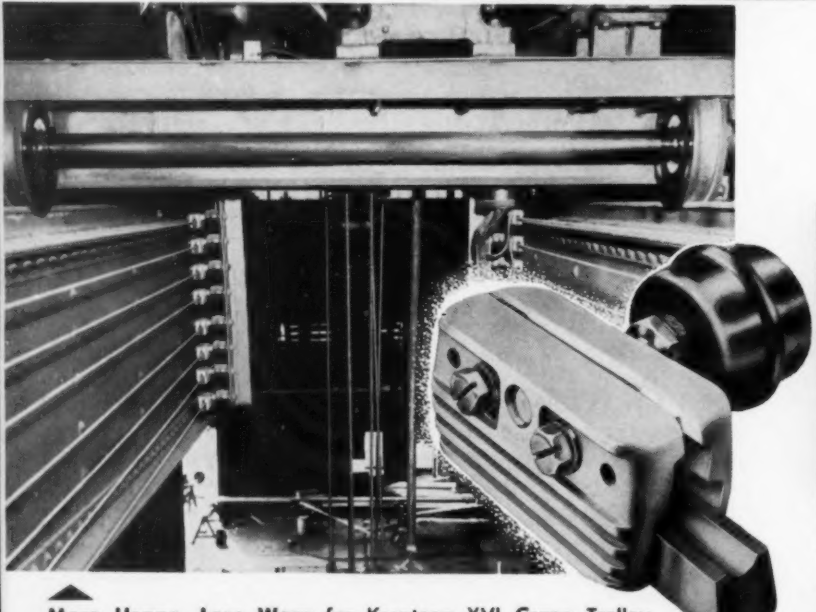
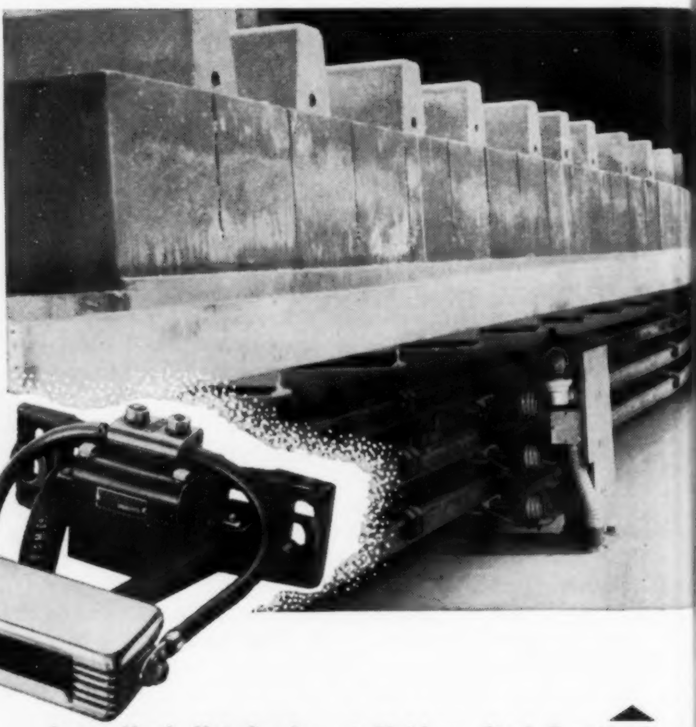


More Usage, Less Wear for Keystone XVI Crane Trolley Collectors. Installed on an overhead crane the same day wheel-type collectors went on a similar crane, they were in operation 50% longer each day. When wheels were removed due to failure, the XVI renewable carbon shoe contact inserts still had many months of life ahead.



Long, Hard, Hot Service at Birdsboro Steel Foundry & Machine Co. Loaded furnace cars move in and out of heat treating furnaces safely and without a hitch. Rails on each furnace car contact stationary columns equipped with Keystone LMI Pony-size Contact Rail Collectors. These reversible collectors offer 30% greater contact travel, efficient current transfer.

Rugged Reliability in the face of dirt, rainy and icy conditions, and severe misalignment. These Keystone Inverted-V Universal Collectors have operated for more than seven years at the Alan Wood Steel plant. They give positive contact wherever the going is rough, tough, and dirty—in open hearth, coke plant, blast furnace.

ELECTRIC SERVICE MANUFACTURING CO.,

third-rail problems on his desk!

Engineer will collaborate and . . .

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ESM PRODUCTS ARE JOB-PROVED—They're at work on all types of materials handling equipment in every industry—steel mills, power plants, docks, rail yards, processing plants. Typical installations shown here illustrate the scope and reputation of Electric Service in this electrical power-transmission field.

What's your problem?—insufficient power? . . . severe weather or corrosion conditions? . . . production-sapping shutdowns? . . . excessive maintenance? Write today for assistance.

▲ **Aluminum Reduces Corrosion,** cuts deadweight for Canton Co. Baltimore Harbor's salty dampness doesn't faze Keystone Integrated Aluminum Conductor System. High-speed ore unloader utilizes aluminum on trolley conductors and on 1200-ft., 2300-volt main runway. Aluminum Under-running System has high current capacity, low voltage drop, sensitive control.

Unhurt by Volts, Jolts are the Keystone Insulators on Fairless Works coke oven rails. Petticoat-type Porcelain Insulators resist contamination by dirt, moisture. Shock-proof, non-absorbent moulded type Insulators team up to protect over-running contact rails under severe conditions. ▼

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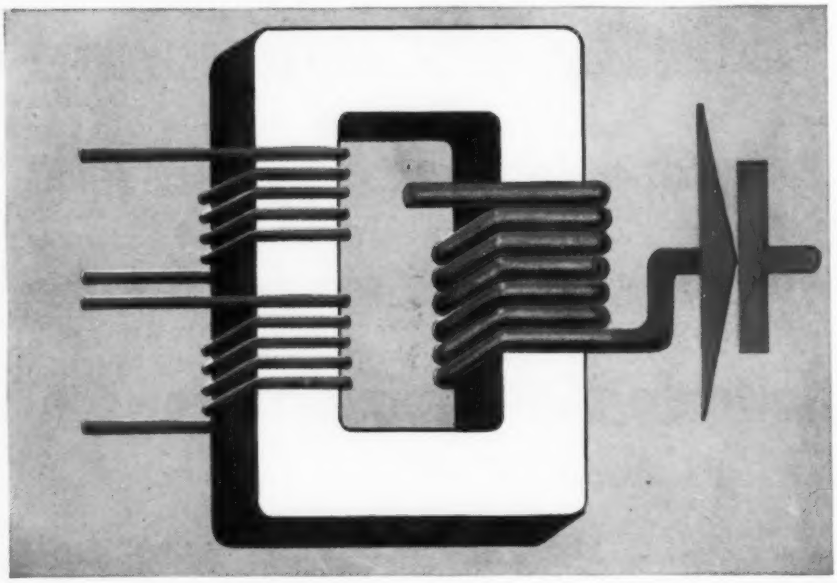
Represented in Canada by Lyman Tube and Bearings, Ltd., Montreal and Toronto

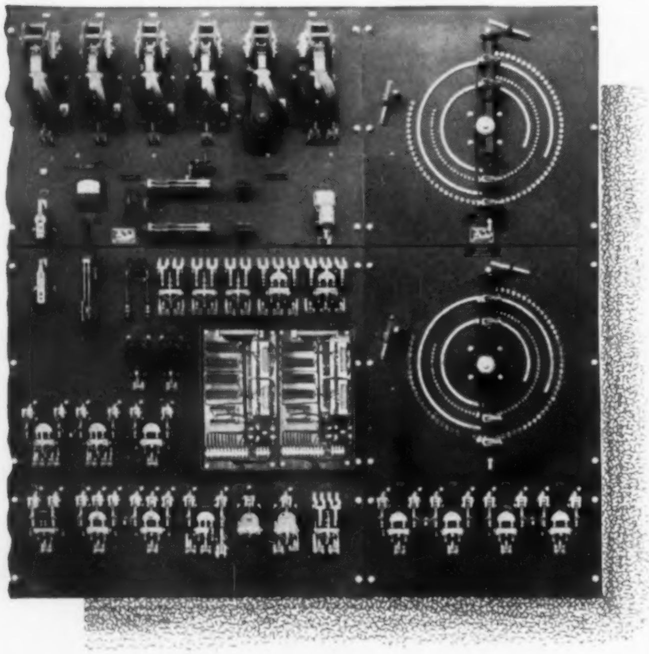
CLARK *Magnetic Amplifier*

regulates without tubes or moving parts

The CLARK Magnetic Amplifier has the ability to amplify a small signal current, thus making it ideal for service in voltage regulation, speed control, positioning, tension control and accelerating applications.

Built like a transformer, with no moving parts or tubes, it is unaffected by shock and vibration. It requires no warm-up period and practically no maintenance. It is rugged and reliable, and does not get out of adjustment.





The picture shows CLARK Magnetic Amplifiers applied to Motor Operated Rheostats. No contacts are required in the motor circuit to reverse rotation. Pre-selected positions on the rheostats are provided by Push Button and Potentiometer remote control, or combinations of any desired number.

Within a range of 5 to 20 seconds, any selected rate of travel in either direction is available. There is continuous adjustment of position, and the speed of response prevents hunting or overshooting. Accuracy is maintained within one button on the Motor Operated Rheostat.

The power requirement is very low.

Greater production, finer performance and more uniform operation in a broad variety of applications in industry result from the use of CLARK MAGNETIC AMPLIFIERS.

Write for your copy of "Magnetic Amplifier Applications for Modern Industry," or call your nearest CLARK representative.

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Iron AND Steel ENGINEER

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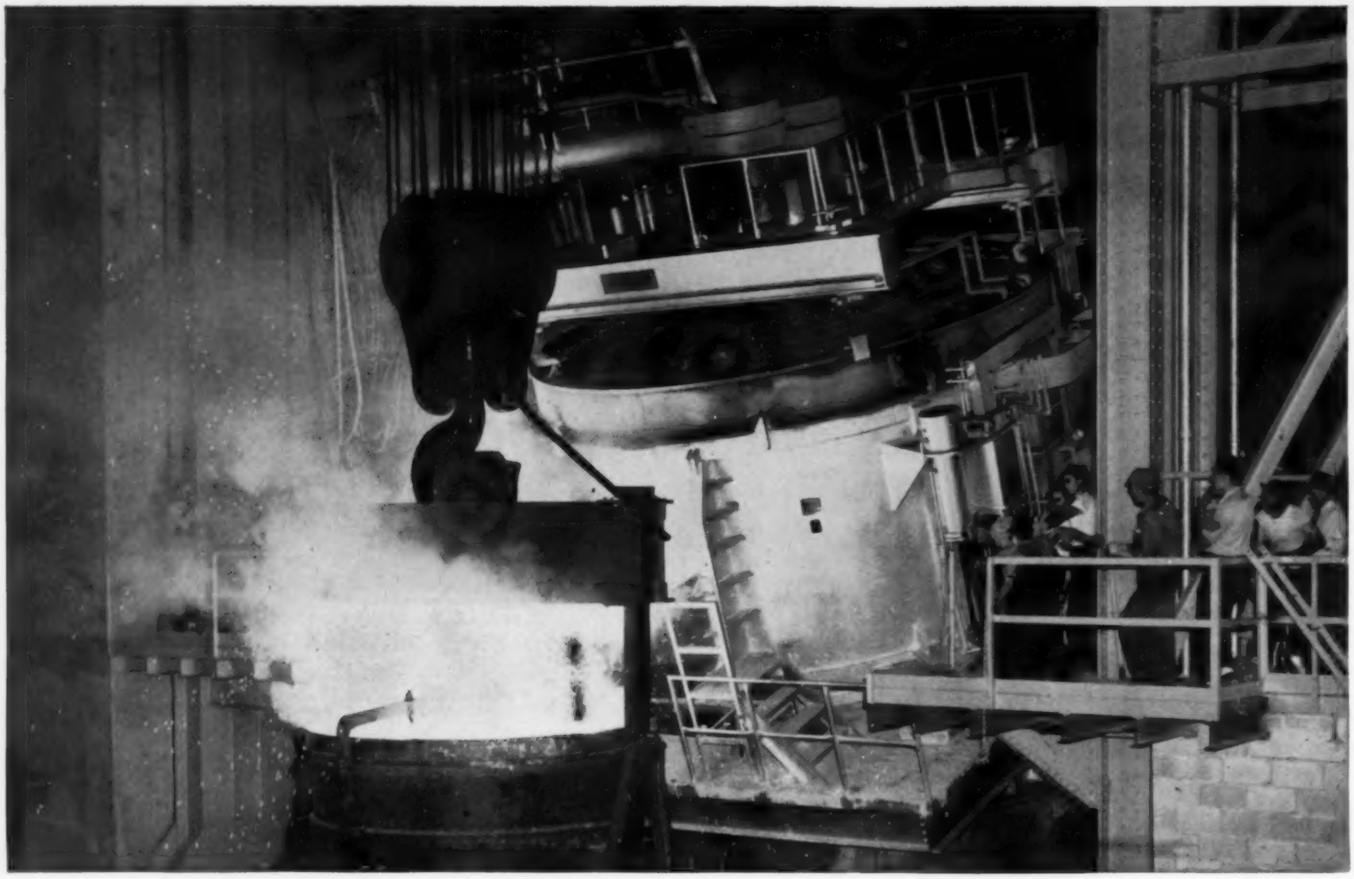

Atlantic Steel's 75-ton baby ***breaks records for 2nd birthday***

On May 13th Atlantic Steel Company in Atlanta celebrated the 2nd birthday of their 75-ton Lectromelt* Furnace. Look at how they have increased its production with experience . . .

RECORD HEATS	Feb. 15, 1953—84 tons for 41 ingots Feb. 8, 1954—88.15 tons for 43 ingots
DAILY RECORD	March 7, 1953—460.3 tons Nov. 5, 1953—473 tons
WEEKLY RECORD . .	April 19-25, 1953—16 tons/hour for 35 heats averaging 76.7 tons/heat and totaling 2,684 tons Nov. 1-7, 1953—16½ tons/hour for 39 heats averaging 77.7 tons/heat and totaling 3,031 tons
MONTHLY RECORD . .	March 1953—10,890 tons March 1954—11,894 tons

According to Atlantic they are constantly obtaining more consistent, higher quality, and are planning to let the Lectromelt carry their major production load, firing up their open hearths only as required.

Write for Bulletin #9 describing Lectromelt melting furnaces and components. Pittsburgh Lectromelt Furnace Corporation, 310 32nd Street, Pittsburgh 30, Pennsylvania.

Manufactured in . . . GERMANY: Friedrich Kocks GMBH, Dusseldorf . . . ENGLAND: Birlec, Ltd., Birmingham . . . FRANCE: Stein et Roubaix, Paris . . . BELGIUM: S. A. Belge Stein et Roubaix, Bressoux-Liege . . . SPAIN: General Electrica Espanola, Bilbao . . . ITALY: Forni Stein, Genoa. JAPAN: Daido Steel Co., Ltd., Nagoya

TWENTY FIVE POUNDS TO ONE HUNDRED FIFTY TONS CAPACITY

*REG. T. M. U. S. PAT. OFF.

MOORE RAPID

WHEN YOU MELT... *Lectromelt*

CONTROL AND DRIVE EQUIPMENT ON D-C ELECTRIC TRAVELING CRANE BRIDGES

By D. C. McCRADY
Superintendent, Electrical Dept.
The Steel Co. of Canada, Ltd.
Hamilton, Ontario, Canada

. . . . control and drive equipment must be engineered together if cranes are to give satisfactory service . . . .

▲ VARIOUS complaints and troubles associated with crane bridge drives have long been a source of annoyance to steel mill maintenance personnel. The usual cycle, which consists of: crane too sluggish; reduce resistors and timing; motor burns out; change to larger motor; plugging too severe at high speed; axle breakage; increase plugging resistor; crane too sluggish, and so on, is familiar, with many variations, to all. Much of the problem seems to lie in all of its factors not being too well understood. Although the latest AISE Specification No. 6 does cover a means of specifying crane drives, and appears satisfactory for hoists, there are drawbacks to the method of selecting bridge and trolley drives. Moreover, the control generally supplied by the electrical manufacturers does not allow for the variables involved in a really practical manner. This is no fault of theirs, since there has never been advocated a practical simple method of tying the electrical and mechanical features together. This the author has attempted to do, as well as suggest a more practical method of specifying crane operating characteristics and determining gear ratio, motor size, and control layout. For purposes of discussion, d-c mill type series wound totally enclosed motors only will be considered, and the 60-minute rating will be referred to, although all calculations, formulae, and curves could as easily be derived for the 30-minute ratings of the same line of motors.

The author will first define the type of control which will, for purposes of this paper, be considered standard, then proceed to correlate the crane acceleration or "snappiness" with the motor or resistor heating problem, and finally work out a means of specifying control resistor layout, size of motor, and gear ratio from the specified operating characteristics.

GENERAL CONTROL LAYOUT

In general, bridge control has been furnished in recent years with three or four steps of acceleration, and one step of plugging, with timing or current limit relays used for the acceleration steps, and some form of plugging relay used for the zero speed cutout of the plugging resistor section. It is suggested that for bridge and trolley drives:

1. Three steps of acceleration be standard.
2. Two steps of plugging be used.
3. Average plugging effort *at* the wheels be equal to average accelerating effort.

Three steps of acceleration are adequate for all needs, the fourth step reduces peaks only by about 6 per cent for the same average current. If three steps are employed for acceleration to a point where the motor counter voltage is 100 per cent, that is, to base speed, surely two steps are required to bring the motor to standstill, when often more than double voltage is available at the motor terminals at the instant of plugging, due to the change in field strength. If, as is customary, only one step is used, either the plugging torque available at low speeds will be inadequate for good spotting, or the torques applied at the instant of plugging will be excessive, causing both mechanical and electrical breakdowns if they are used repeatedly. With two steps of plugging, and relaying arranged for equal peaks and valleys of current, and the average plugging force at the wheels equal to average accelerating force at the wheels, the operating characteristic appears as in Figure 1. The plugging currents are less than accelerating currents for the same wheel effort, due to the drive efficiency. Values are plotted on a per unit basis, where 1.0 represents rated 60-min motor speed and current. Note that the current on the first point, before the second plugging resistor is cut out, is a little more than half the average accelerating current. That is, from standstill, the first point on the controller will give a low torque point, with the first plugging resistor section automatically cut out. By cutting out the first plugging step by means of a voltage relay, and using a two point (2 forward, 2 reverse) controller, the second point will allow full rate of acceleration to top speed. Other intermediate points of course may be added if desired.

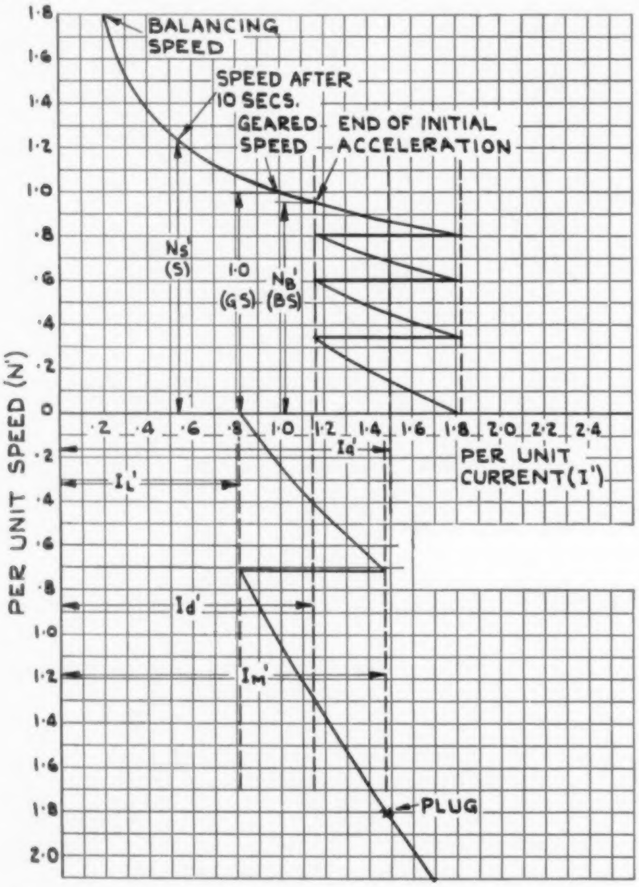

Figure 1 — Curve shows a typical plugging cycle on a crane which has been designed for equal peaks and valleys of current.

Assuming the above general ideas on control layout, the method of specifying the drives will now be considered.

INITIAL ACCELERATION AND MOTOR HEATING

From the operator's viewpoint, "snappiness" of a crane is important. From the technical viewpoint, "snappiness" is synonomous with initial acceleration rate on the resistor, and the related plugging rate as already defined. Average accelerating rates on the resistor vary from 0.75 up to 2.5 fps/sec for various applications. (Practically speaking, the time to travel 8 feet from rest gives a good measure of initial acceleration rate, and can be used for judging comparative crane performance.)

From the motor heating standpoint, due to the fact that the generated heat varies with the square of the current, we can practically say that motor heating depends on the percentage of time that the motor operates on the resistor (that is, at the heavier current values). This associates the resistor and motor thermal ratings. The amount of time that the motor operates beyond or above "base speed" (N_B' on Figure 1) does not contribute appreciably more to motor heating than does the standstill condition with the power off. Consequently it appears reasonable to define the motor heating characteristic (as well as resistor design) on the basis of per cent time on a cycle consisting of repeated acceleration to what might be termed "base speed" and immediate plugging to standstill. (If we use a motor, and a control which permits peaks of 200 per cent current on each accelerating cycle, the same motor can operate for a greater per cent of the time on a cycle allowing 150 per cent current peaks.) Various classes of cranes can be chosen, based on the relative heating effects of their duties, but referred for the sake of calculations to the per cent time on the above hypothetical duty, namely, repeated acceleration and plugging.

The author has chosen three such classifications, denoting them as standard, medium, and heavy duty; they correspond mathematically to 7½, 10 and 15 per cent time on the resistor. This can be shown (see appendix) to represent *average* accelerating currents of 172, 148, 124 per cent respectively, or *average* accelerating torques at the motor of 200, 167, 133 per cent respectively. The above general statements can be made, since all steel mill type motors have about the same operating and heating characteristics on a per unit basis, unity representing the 60-minute values. Most steel mill crane bridge and trolley drives fall within these three classifications. (Note that AISE Standard No. 6 assumes the 200 per cent or what the author has denoted as standard duty average torque, and then employs multipliers to determine heavier duty horsepower ratings.)

It can be shown (see appendix) that, once the average accelerating current is chosen, the peak and valley values are automatically set, for any given number of steps. So assuming three steps, Table I shows the per cent accelerating currents required for the three duty classifications. This table will allow design of the accelerating resistor, ignoring NEMA classifications entirely. Actually the NEMA resistor classification is not well adapted to crane bridge control design, as the real duty selection is not too adequately specified.

As far as plugging is concerned, again assuming two steps of plugging from the expected top or balancing speed of the crane, the peak and valley values of current can be shown (see appendix) to follow the curves of Figure 2. Peak (I_M') and valley (I_L') values are plotted against top or balancing speed, all on a per unit basis, for each of the three classifications. The curves are based on the same plugging torque *at the wheels* as for acceleration. Again, the resistor can be designed from this data, as follows. Assume the crane will reach a top or balancing speed of 180 per cent, by using the standard mechanical formula and an assumed pounds per ton friction. Then the peak current will be (for medium duty) 148 per cent and the valley value 81.5 per cent. The total resistor must limit the current to 148 per cent at a speed of 180 per cent; if the normal running motor speed at 148 per cent current is, say, 87 per cent (from the motor curve), then the total resistor should be

TABLE I

Duty	Average accelerating current, per cent	Per cent ohms first step R	Peak value, per cent	Valley value, per cent	Per cent time on
Standard	172	47.7	210	134	7½
Medium	148	55.7	180	115	10
Heavy	124	66.3	151	97	15

Resistor with first step cut out = 0.570 R
Resistor with two step cut out = 0.245 R

$\left(1+\frac{1.80}{0.87}\times\frac{(100)}{(1.48)}\right)$ or 207 per cent ohms. The total resistance after the first step is cut out is of course $\left(\frac{1}{0.815}\times 100\right)$ or 123 per cent ohms.

Table I and Figure 2, that the size of resistor from a heating standpoint be worked out based on a hypothetical duty of 7½, 10, or 15 per cent time on, using the current values shown. In some manner the electrical manufacturers could relate their resistor continuous unit ratings to a duty such as the above. For instance if the motor is to operate 10 per cent of the time on the resistor, each portion of the resistor would have the currents mentioned above flowing for different portions of this ten per cent. A table could be worked out relating continuous current capacity to either plugging or accelerating sections, for different total-cycle per cent time-on-values. This is, of course, a question of design on which the author will not attempt to elaborate.

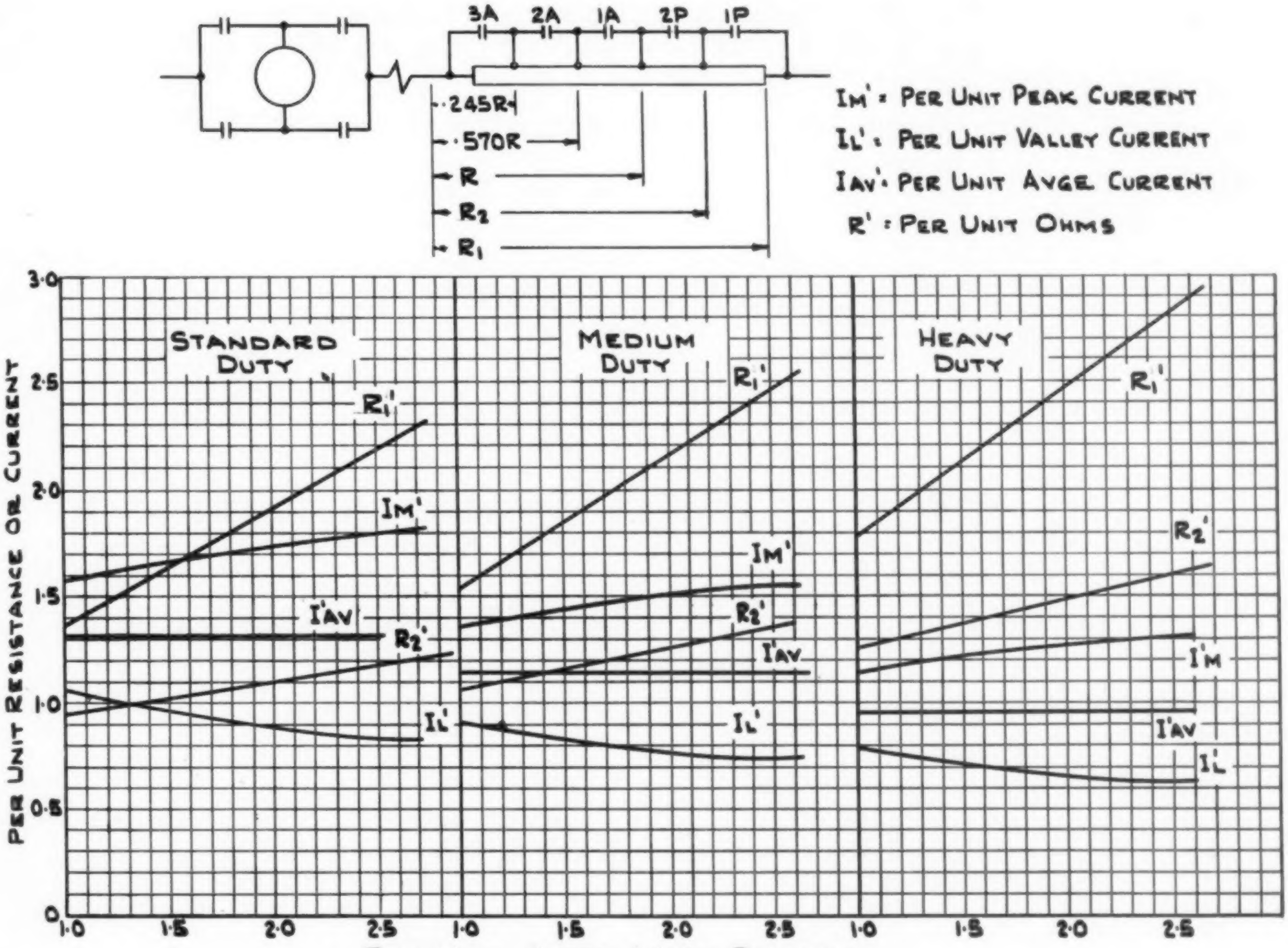

Figure 2 — Peak and valley values of current assuming two steps of plugging from top speed of crane will follow the curves here shown.

These calculations all neglect the motor armature and field resistance, but the errors involved in so doing, are negligible. The curves of Figure 2, show these resistor values on a per unit basis as a function of top or balancing speed.

The author would suggest that, having determined the ohmic values of the resistor steps in accordance with

CRANE SPEED

Having indicated a relationship between motor heating, the rate of acceleration and deceleration, and crane duty, it now remains to indicate a method of selecting the motor size (and gear ratio) so that the per unit and per cent values already mentioned, will become definite design values.

Crane speeds have been variously defined as top or balancing speed, and geared speed or the speed in feet per minute at the motor rated rpm. From a practical operating standpoint, geared speed means nothing. Top speed is, on the other hand, rather indefinite, due to the fact that great variations in friction values occur with different designs. The author has personally observed 9 to 15 pounds per ton variation on the same crane, under different circumstances, with roller bearings.

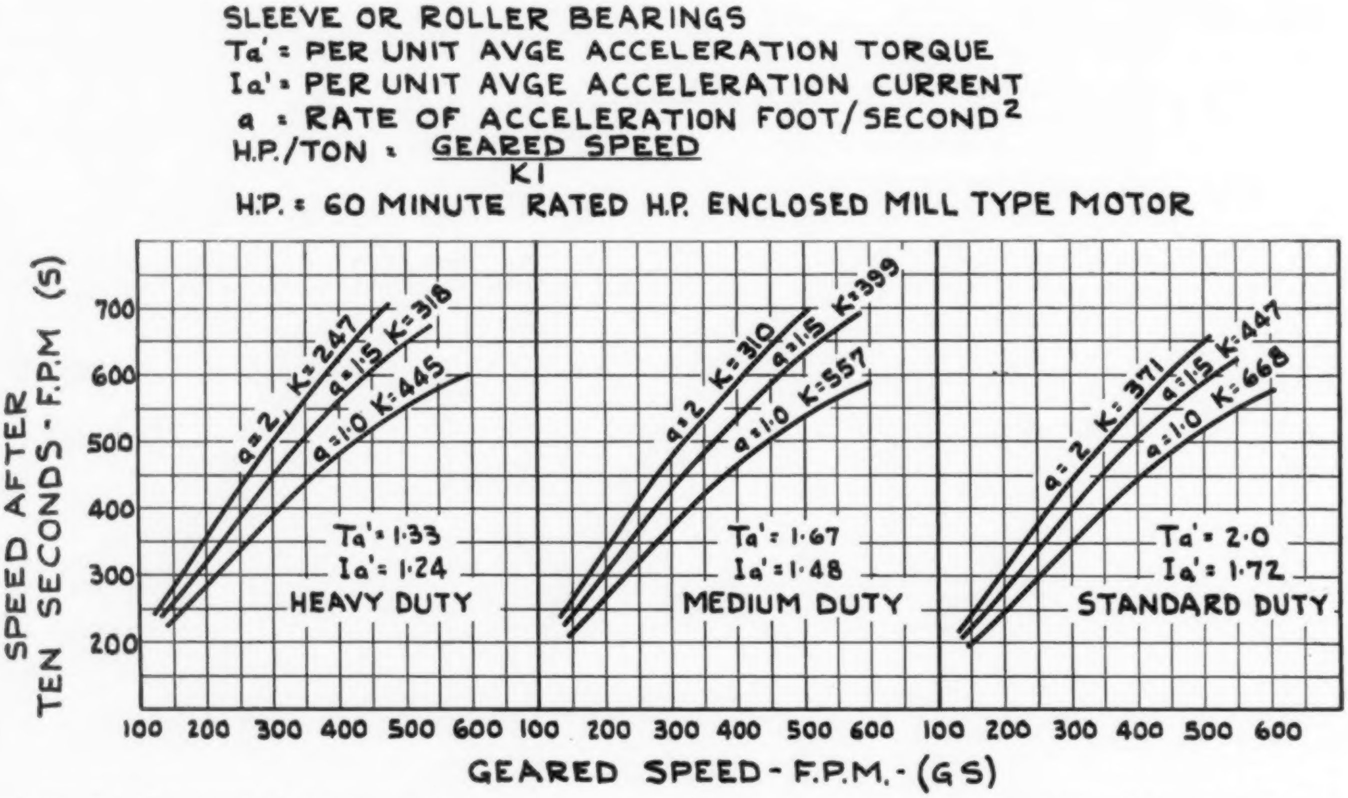

Figure 3 — The speed after ten seconds may be a more important function in designing bridge drives than the top or balancing speed.

A new approach to the problem was suggested a couple of years ago in a paper presented in England by Wise and Bramley ([2]), wherein they suggest that speed performance be judged by the "speed after ten seconds from rest". Their paper includes a large number of tests to substantiate the fact that this quantity, along with initial rate of acceleration, thoroughly classifies a crane from the operating viewpoint. Moreover, this speed is easily measured, compared with top speed, where a long run is often necessary.

The author has moreover proven (see appendix) that this speed is practically independent of the friction value — from 10 up to 25 pounds per ton — which covers the whole range of both antifriction and sleeve bearings. It is therefore a practical yardstick, and can be used to compare cranes of all sorts.

To bring this quantity "speed after ten seconds" which itself depends on the initial rate of acceleration to some extent, into relationship with the geared (or design) speed of the crane, requires an integration of the speed-time relationship after the motor is off the resistor (see appendix). This the author has done, and the results are shown in Figure 3. Each group of curves represents one duty classification. Each curve of a group represents a rate of initial acceleration: 1.0, 1.5, or 2.0 fps per sec. From the curve can be chosen the geared speed corresponding to speed after ten seconds. The horsepower (60 min) per 2000 lb ton weight of the crane is given by:

$$\text{Hp per ton} = \frac{\text{Geared speed}}{K_1} \quad \text{where } K_1 \text{ is a constant}$$

whose value depends on the curve being used. Its derivation is given in the appendix to this paper. From the geared speed of course, the gear ratio is evident as:

$$\text{Gear ratio} = \frac{\text{Motor 60-minute rated rpm}}{\text{Geared speed fpm}} \times \frac{\pi}{12} \times$$

wheel diameter in inches.

Note that the above selections ignore the type of wheel bearings entirely.

With the motor 60-minute hp chosen, and its rated current of course known in amperes, the resistor can be designed from Table I and Figure 2.

SUMMARY

To sum up, the design of crane bridge and trolley drives should represent a co-ordination of motor, gear ratio, and resistor design along lines which can be co-related with the performance specified, and the conditions under which the crane will be required to operate. To this end, the author suggests that:

1. Performance be defined by:
   a. Initial rate of acceleration on the resistor, or "snappiness."
   b. Speed after ten seconds from rest, or "distance handling ability."
2. Operating conditions be defined by:
   a. Per cent time on a hypothetical duty cycle consisting of repeated acceleration to base speed and plugging to a stop. This places cranes in one of several classifications to be denoted as standard, medium, and heavy duty.
3. Control be standardized on the basis of three acceleration and two plugging steps, with equal peaks and valleys of current for each step of acceleration and of deceleration; the average effort at the wheels for acceleration and deceleration being equal.
4. Motor horsepower, gear ratio, resistor and timing (or current limit) layout be based on results of 1, 2 and 3 above.

As examples, an open hearth charging machine would be heavy duty; a ladle crane standard duty; a scrap preparation crane heavy duty; mill cranes medium duty; coil storage cranes heavy duty; shipping cranes standard or medium duty. Classifications would have to be worked out from experience.

As an appendix to this paper, examples have been worked out, using the curves which have been derived.

APPENDIX "A"

TYPICAL EXAMPLE OF CRANE BRIDGE CALCULATION

Given — Crane weight 60 tons, acceleration 1.5 fps per sec, speed after ten seconds 450 fpm, medium duty, wheel diameter 24 in.

Geared speed from Figure 1 — 320 fpm and $K_1=399$; $I_a'=1.48$

$$\text{Motor hp}=\frac{\text{Geared speed}\times\text{tons weight}}{K_1}=\frac{320\times 60}{399}=48.$$

Nearest 60-min rated enclosed mill motor frame 610 — 50 hp — 500 rpm.

$$\text{Gear ratio}=\frac{\text{Rpm}}{\text{GS}}\,\pi\,\frac{D}{12}=\frac{500}{320}\,\pi\,\frac{24}{12}=9.82 \text{ to } 1.$$

Full load current (60-min) = 180 amp

Average accelerating current = $1.48\times 180=266$

Peak current for three step acceleration = $1.80\times 180=$ 325 amp (Table I)

Min. current for three step acceleration = $1.15\times 180=$ 208 amp (Table I)

Crane has roller bearings, so assume friction at 12 lb/ton

Motor torque at balancing speed =

$$\frac{\text{lb/ton}\times\text{tons weight}\times\text{wheel diam in inches}}{\text{gear ratio}\times\text{efficiency}\times 24}$$

$$=\frac{12\times 60\times 24}{9.82\times 0.85\times 24}=86.2 \text{ lb-ft}$$

Motor speed from frame 610 curves at 86 lb-ft is about 900 rpm

This value is $\frac{900}{500}=1.8$ or 180 per cent of rated speed.

Peak current for 2-step plugging (from Figure 2) = $1.48\times 180=267$ amp

Minimum current for 2-step plugging $0.8\times 180=148$ amp

Stalled motor current on first controller point (one step of plugging cut out) will be 148 amp

First plugging step should cut out when current drops to 148 amp or at a speed of about 71 per cent of full load speed.

The voltage will be $\frac{540}{440}\times 0.71\times 230=200$ volts, where

540 and 440 rpm are the motor normal speed corresponding to 148 and 267 amp respectively.

$$\text{Motor 100 per cent ohms}=\frac{230}{180}=1.28 \text{ ohms}$$

Total plugging + accelerating resistor = $1.28\ R_1'=1.28\times 2.03=2.60$ ohms

Second plugging + accelerating resistor = $1.28\ R_2'=1.28\times 1.22=1.56$ ohms

Total accelerating resistor = $1.28\ R'=1.28\times 0.557=0.713$ ohms

Second accelerating resistor = $0.570\times 0.713=0.407$ ohms

Third accelerating resistor = $0.245\times 0.713=0.175$ ohms

APPENDIX "B"

TYPICAL CASE OF MISAPPLICATION

Charging machine — Weight 115,000 lb (57.5 tons)
Wheels driven: four 30-in. diameter, sleeve bearings
Gear ratio — 15.95 : 1
Motors: two — MCA-40, 20 hp, 600 rpm (in parallel)
Frequent motor burn-outs.

Present rate of acceleration is about 2 ft/sec/sec.

$$\text{Present geared speed}=\frac{600}{15.95}\,\pi\,\frac{30}{12}=296 \text{ fpm}$$

$$\text{Value of } K_1=\frac{\text{Geared speed}\times\text{tons}}{\text{Hp}}=\frac{296\times 57.5}{2\times 20}=425$$

Even a standard duty crane would have K_1 equal to only 371 for an acceleration rate of 2.0. Actually, a charging machine requires at least medium duty, and the author would suggest heavy duty.

Also note that speed after 10 seconds for such a machine need only be around 300 fpm at the most. Hence the following proper selection of a drive:

Geared speed for heavy duty and 2 ft/sec/sec is 160 fpm

$$\text{Value of } K_1=247 \quad \text{Motor hp}=\frac{160\times 57.5}{247}=37.3$$

So that the two 20 hp motors are still adequate.

$$\text{Gear ratio should be: }\frac{296}{160}\times 15.95=29.5$$

Mechanically this would have required a third gear reduction, but control would have provided accelerating currents of 125 per cent instead of present 200 per cent (worse than standard duty) and motor burn-outs would be avoided.

If present gear ratio had to be maintained, or a geared speed of 296 fpm then $hp = \frac{296 \times 57.5}{247} = 69$ or two 35-hp motors.

Their speed at full load (modern frame 608) is 525 rpm so actual gear speed is $\frac{525}{600} \times 296$ or 259 fpm and actual required $hp = \frac{259}{296} \times 69 = 60.5$ hp. This allows ample margin for two 35-hp motors, but speed after 10 seconds will be 450 fpm or much faster than necessary.

APPENDIX "C"

1. It has been found that totally enclosed series wound mill type motor all have roughly the same characteristic curves on a per unit basis. If per unit values of current versus torque (I' vs T') are plotted, then for values above full load $I' = 0.28 + 0.72T'$ . . . . (1)

   Again if per unit values of hp or of $T'N'$ are plotted against T' various equations apply for different portions of the characteristic curve.

   $T'N' = 0.14 + 1.1T'$ . . . . (2)

   For speed above 150 per cent of rated 60-min speed.

   $T'N' = 0.28 + 0.72T'$ . . . . (3)

   For speed below 150 per cent of rated 60-min speed up to values of 125 per cent of full load torque.

   $I'N' = 0.33 + 0.67\ I'$ . . . . (4)

   For values of I' from 70 up to 125 per cent current.

Remembering that with per unit values, unity represents the full load values (60-min rating) such as geared speed and rated hp. The above equations are of course approximations, but are sufficiently accurate for the purposes to which they will be put in the following discussions.

2. Tractive effort at the wheels for acceleration of "a" ft per sec per sec is equal to

   $$TE_a = \frac{2000a \times 1.08}{32.2} + F = 67a + F \text{ lb per ton} \ldots (5)$$

   Where F lb per ton friction and the WK^2 of rotating parts is assumed at 8 per cent of crane weight.

   $TE_d = 67\ d - F$ lbs per ton . . . . (6)

   Where d = rate of deceleration or plugging ft per sec per sec.

   Now if per unit accelerating torque *at* motor is T_a'

   Then actual torque $= \frac{HP_R \times 5250 \times T_a'}{N_R}$ lb-feet.

   Where HP_R = motor rated HP and N_R full load speed.

$$\text{So } TE_a = \frac{HP_R \times 5250}{N_R} \times \frac{T_a' \times E \times G}{D/24} \times \frac{1}{\text{ton wt}} \text{ lb/ton}$$

Also geared speed $GS = \frac{N_R}{G} \pi \frac{D}{12}$ fpm

Where D = wheel diameter inches and G gear ratio.

Where E = drive efficiency (usually taken as 0.85).

Equating the two values of TE_a we get:

$$67\ a + F = \frac{HP/ton \times E \times T_a' \times 33000}{GS} \ldots\ldots\ldots\ldots (7)$$

$$\text{Also } 67\ d - F = \frac{HP/ton \times T_d' \times 33000}{E \times GS}$$

If we call the ratio $\frac{GS}{HP/ton} = K_1$

$$\text{Then } HP/ton = \frac{GS}{K_1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$\text{and } K_1 = \frac{33000\ E\ T_a'}{67a + F} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

The value K_1 is really an acceleration factor. It depends on a and F as well as the value of T_a' which can be allowed, but the value of F does not affect appreciably the value of K_1.

AISE specifications allow $T_a' = 2$, but for many applications this value allows too much heating. The following suggests a method of assessing the heating factor.

3. No matter what the crane application, the heating can be assessed as a proportional function of the most severe duty. The most severe cycle which can be used is repeated acceleration on the resistor and immediate plugging to a stop. If values of a and d are assumed, the corresponding values of I_a' and I_d' can be calculated, and hence an RMS value, provided the per cent time-on is known. This is all worked as follows:

   If we allow the rate of deceleration (plugging) to be such that the same effort *at* the wheels is provided as for acceleration, which is a reasonable assumption, then $67a + F = 67d - F$ and the value of T_d' is given by $T_d' = T_a' \times E^2 = 0.72\ T_a'$.

   Using an average rate of acceleration a = 1.5 and friction F = 17 lb/ton will make d = 2 ft per sec per sec.

   Actually, the values of a and F chosen do not affect the heating factor to any appreciable extent.

   Now we can convert values of T_a' and T_d' to per unit current values.

Motor current $I_a' = 0.28 + 0.72\ T_a'$ from (1).

$I_d' = 0.28 + 0.52\ T_a'$ since $T_d' = 0.72\ T_a'$.

Time to accelerate to V fps $t_a = \frac{V}{a}$ and $t\,d = \frac{V}{d}$ for plugging.

If per cent time-on is p, then total time $= \frac{100\ (ta + td)}{p}$

On totally enclosed mill motors, continuous rating corresponds to about 43 per cent of full load 60-min current or a value of $I' = 0.43$

$$\text{Then } \sqrt{\frac{I_a'^2 t_a + I_d'^2\ td}{\frac{100}{p}(t_a + t_d)}} = 0.43$$

$$\text{Then } p=\frac{18.5\ (t_a+t_d)}{I_a'^2t_a+I_d'^2t_d}=\frac{18.5\left(\frac{1}{a}+\frac{1}{d}\right)}{\frac{I_a'^2}{a}+\frac{I_d'^2}{d}}=$$

$$\frac{64.8}{2\,I_a'^2+1.5\,I_d'^2}\quad \text{since } a=1.5,\ d=2.0$$

$$p=\frac{45.5}{T_a'^2+0.861\quad T_a'+0.19}\qquad\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

Figure 4, shows a plot of this relationship. This provides a yardstick for figuring duty versus average accelerating torque. Normally, a value of 7½ per cent or $T_a'=2$ gives good service, as already mentioned.

4. The speed after 10 seconds can be plotted as a curve against GS (geared speed) for various values of a, F, and T′. These are shown in Figure 3 for F=17 lb per ton. The three values of $T_a'=1.33$, 1.67 and 2.0 correspond to heating factors of 15, 10 and 7½ per cent time-on the resistor. The derivation of these curves is as follows:

   Referring to Figure 1, the crane is accelerated on the resistor at an average torque of T_a' to a speed N_B'. The acceleration to "speed after 10 sec" N_S' takes place along the normal series motor characteristic curve. The actual FPM values corresponding to the above per unit values are BS for N_B', GS for unity (1.0), and S for N_S'.

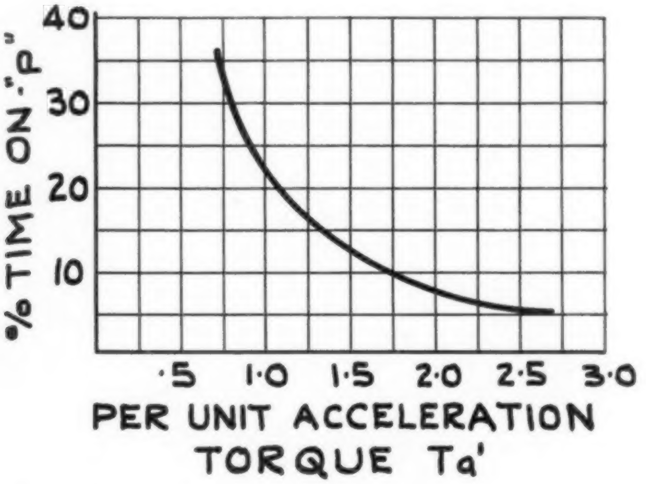

Figure 4 — Curve gives a means for comparing duty against average accelerating torque and is based on 100 per cent RMS load.

It can be shown that for 3-step resistor acceleration with equal current peaks and valleys, that the low or valley current value is equal to 0.776 I_a' where I_a' is the average current. Thus for any value of T_a' the value of N_B' can be calculated from equations (1) and (3), i.e. I_a' can be obtained from (1), hence a value of valley current I_B'; hence T_B' from (1) again, and finally N_B' from (3).

The time to accelerate to N_B' is given by

$$\frac{BS}{60a}=\frac{N_B'\times GS}{60a}$$

The total time to reach S is 10 seconds. The time to go from speed N_B' to N_s' is $10-\frac{N_B'\times GS}{60a}$ and a small increment of this time is dt

$$dt=\frac{ds}{60\times\text{rate of acceleration}}$$ seconds, where ds is the change in FPM speed.

The rate of acceleration is given by

$$\frac{I}{67}\left(\frac{33000\ ET'}{K_1}-F\right)\ \text{at any point (from 9)}$$

$$\text{Then } dt=\frac{\frac{67}{60}\ ds}{\frac{33000\ ET'}{K_1}-F}$$

Also $s=N'\times GS$ so $ds=GS\ \times\ dN'$

and $T'=\frac{0.28}{N'-0.72}$ from (3)

$$\text{Then } dt=\frac{\frac{67}{60}\ dN'\times GS}{\frac{33000\ E}{K_1}\left(\frac{0.28}{N'-0.72}\right)-F}$$

Integrating, we have:

$$10-\frac{N_B'\times GS}{60a}=\int_{N_B'}^{N_S'}\frac{\frac{67GS}{60}\ (N'-0.72)\ dN'}{\left(\frac{33000\times0.28E}{K_1}+0.72F-FN'\right)}$$

$$=\ \frac{67GS}{60}\int_{N_B'}^{N_S'}\frac{(N'-0.72)\ dN'}{K_2+0.72F-FN'}$$

$$\text{where } K_2=\frac{33000\times0.28\times E}{K_1}=\frac{0.28\ (67a+F)}{T_a'}\qquad\ldots.(11)$$

$$\text{Then }\left(10-\frac{N_B'\times GS}{60a}\right)\frac{60}{67GS}=$$

$$\left[\frac{0.72-N'}{F}-\frac{K_2}{F^2}\ \log_e\ \left(K_2+0.72F-FN'\right)\right]_{N_B'}^{N_S'}$$

$$\text{Therefore: }\frac{600}{67GS}\ -\ \frac{N_B'}{67a}=$$

$$-\frac{K_2}{F^2}\ \log_e\ \left(\frac{K_2-F\ (N_S'-0.72)}{K_2-F\ (N_B'-0.72)}\right)\ -\ \frac{N_S'-N_B'}{F}$$

$$\text{or } GS=\frac{8.96}{\frac{N_B'}{67a}-\frac{2.303\ K_2}{F^2}\ \log_{10}\left(\frac{K_2-F\ (N_S'-0.72)}{K_2-F\ (N_B'-0.72)}\right)-\frac{N_S'-N_B'}{F}}\qquad(12)$$

By choosing different values of N_S', values of GS can be calculated, and hence S, from $S=N_S'\times GS$, and plotted as a curve of GS versus S (up to values of $N_S'=1.5$ See equation (3).

There will be a different curve for each value of a, F, and N_B'. The value of N_B' of course depends on T_a' and can be calculated from it, as shown previously.

For values of N_S' above 1.5 since $T'=\frac{0.14}{N'-1.1}$ the values of GS are calculated as above, the denominator is calculated in two parts, one using $N_S'=1.5$, the second thus:

$$\left(\frac{2.303\,K_3}{F^2}\log_{10}\frac{K_3-F\,(N_S'-1.1)}{K_3-F\,(1.5-1.1)}+\frac{N_S'-1.5}{F}\right)$$

where $K_3=\frac{33000\times 0.14\times E}{K_1}=\frac{K_2}{2}$

Actually it will be found that values of F between the extremes of 10 and 25 do not change the value of GS for a given value of S by more than 6 per cent from the mean value of F (17 lb/ton) used in calculating the curves. Nor does the value of F affect appreciably the quantity K_1 which determines the HP per ton value for a given geared speed. Hence the curves in Figure 3 are plotted, using F = 17 lb per ton and can be used for any type of bearings along with the average values of K_1 shown, without appreciable error. The formula for geared speed from which these curves were calculated reduces to GS equals the fraction:

$$\frac{8.96}{\frac{N_B'}{67a}-\frac{K_2}{125.3}\log_{10}\left(\frac{K_2-17\,(N_S'-0.72)}{K_2-17\,(N_B'-0.72)}\right)-\frac{N_S'-N_B'}{17}-A}$$

and $A=\left[\frac{K_3}{125.3}\log_{10}\left(\frac{K_3-17\,(N_S-1.1)}{K_3-6.8}\right)+\frac{N_S-1.5}{17}\right]$

for values of N_S' above 1.5, otherwise $A=0$

$K_2=\frac{0.28\,(67a+17)}{T_a'}$, $K_3=\frac{K_2}{2}$, $S=GS\times N_S'$

$K_1=\frac{33000\times 0.85\times T_a'}{67a+17}$

HP per ton $=\frac{GS}{K_1}$

APPENDIX "D"

PLUGGING

For plugging, assume that the per unit speed at which plugging occurs is N_p'. This should generally be the approximate calculated balancing speed of the crane.

First step or total plugging resistance is R_1', and the peak current is I_M'. Corresponding motor speed when on the line is N_M'.

Then $I_M'\,R_1'=\frac{N_p'}{N_M'}+1$ since the per unit motor voltage is $\frac{N_p'}{N_M'}$ (neglecting armature resistance)

Assume the current is allowed to drop to I_L' and that the average current is to be $I_d'=\frac{I_L'+I_M'}{2}$ where I_d' is the required average plugging current causing a motor torque of about 72 per cent of the accelerating torque used. Motor voltage at minimum current $=I_L'\,R_1'-1$. When the next step cuts in, it is desired to maintain the same peak as before, namely I_M'.

Then motor voltage will rise to

$$\frac{N_L'}{N_M'}\,(I_L'\,R_1'-1)$$

The second step of resistance total is

$$R_2'=\frac{\frac{N_L'}{N_M'}\,(I_L'\,R_1'-1)+1}{I_M'}$$

At standstill $I_L'\,R_2'=1$

Then $\frac{I_M'}{I_L'}=\frac{N_L'}{N_M'}\,(I_L'\,R_1'-1)+1=$

$$\frac{N_L'}{N_M'}\left(\frac{I_L'}{I'_M}\left[\frac{N_P'}{N_M'}+1\right]-1\right)+1$$

or $\frac{I_M'\,N_M'}{I_L'\,N_L'}\left(\frac{N_L'}{N_M'}+\frac{I_M'}{I_L'}-1\right)=\frac{N_P'}{N_M'}+1$

If this equation is satisfied, then equal peaks and valleys will occur during the two step plugging operation from the speed N_p'.

Now we can use values of I_d' corresponding to the three duty classifications considered for acceleration such that the motor torque for plugging is 72 per cent of the accelerating torque. These are $I_d'=1.32$, 1.15, 0.97 for standard, medium, heavy duty cranes.

Now $N'=\frac{0.33}{I'}+0.67$ (see appendix "A" for average characteristic equations) and $I_L'=2\,I_d'-I_M'$

Then $\frac{N_p'}{\frac{0.33}{I_M'}+0.67}+1=$

$$\frac{I'_M}{I_L'}\left(\frac{\frac{0.33}{I_M'}+0.67}{\frac{0.33}{I_L'}+0.67}\right)\left(\frac{\frac{0.33}{I_L'}+0.67}{\frac{0.33}{I_M'}+0.67}+\frac{I_M'}{I_L'}-1\right)$$

Using the three values for I_d' for the three classifications, values of I_M' and I_L' can be plotted against N_p' as in Figure 2.

APPENDIX "E"

ACCELERATING CURRENTS

If the armature and field resistances are ignored, an approximation which does not materially affect the control resistor design from a practical standpoint, it can be shown that the following relationship holds:

$$\frac{I_L'}{I_M'-I_L'}=Y+Y^2+Y^3+\text{——}+Y^n$$

Where n is the number of accelerating steps.

$$\text{and } Y = \frac{I_L' N_L'}{I_M' N_M'}$$

the values I_L' and N_L' are the per unit valley value of current and corresponding speed from the motor characteristic curve, I_M' and N_M' the peak value of current and corresponding speed.

Using the above relationship, and the generalized characteristic curve mill-type motors, it will be found for a 3-step control that the ratio of peak current to average current is 1.223 and the ratio of valley current to average is 0.776, these ratios being identical, regardless of the peak current value used.

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DISCUSSION

PRESENTED BY

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R. J. HARRY, Vice President, The Alliance Machine Co., Alliance, Ohio.

S. Rifkin: The ideas proposed in this paper should be given serious consideration, along with present AISE Standards. Both methods of selecting bridge and trolley gearing emphasize the fact that the rated speed of those motions cannot be based upon rated motor speed. It is necessary to know the actual horsepower output of the motor under "free-running" conditions in order to determine what the speed of the series motor will be, and the gearing for rated bridge or trolley speed must be selected on that basis.

Although Mr. McCrady points out that a crane may never operate at rated speed because of the short distances involved, still that rating can serve as a "bench mark" for specifying the rating of new cranes for similar applications. Of course, the particular application involved must always be taken into consideration. The gearing selected to permit traveling a short distance as rapidly as possible might not be at all satisfactory for traveling the full length of a long runway.

With present-day light-weight trolleys and high-efficiency trolley drives, the method given in AISE standards for selecting bridge or trolley motors sometimes arrives at a recommended motor horsepower rating considerably below the smallest standard AISE rating. In cases of that nature, the AISE method of selecting gear ratios may result in an extremely unreasonable ratio, and it is my personal feeling that the standards should not be followed too closely in that event. For example, on one application that I was asked to check recently, the AISE method of calculation resulted in a recommended gear ratio of 64 to 1; but the crane manufacturer was more interested in using a ratio of 16 to 1. Although the 64 to 1 ratio would have meant considerably less heating of the motor, still the actual horsepower requirement was so much below the smallest AISE standard frame that the 16 to 1 ratio was not at all injurious to the motor, and it was certainly preferable from the viewpoint of crane design.

H. W. Ball: The crane manufacturer prefers that the cranes operate in the lower speed ranges rather than high. The reason for this is due to the ability of the motor to accelerate within the clearances of the gear teeth.

Another factor that should be given consideration is the length of the runway on which the crane operates, in order that one might determine the top speed required. Where cranes operate in comparatively short distances, we find that lower running speeds and fast acceleration give more satisfactory performance.

Bohdan Yagello: The subject of control and drive equipment co-ordination is so broad that the ideas presented touch on the subject altogether too briefly. In the design of a bridge drive, considerable difficulty is experienced in the control of overmotored drives under light load or free running conditions. The degree of overmotoring is determined by the service factor applied and the choice of a size motor closest to that required for the load and service factor.

A recent check on a crane long in service revealed a severe duty application, severe enough to be considered a continuous duty crane. The duty consisted of making up, positioning and handling multi-unit loads from a conveyor line and required jogging, starting, plug-stopping and reversal of a bridge drive. The observer noted with some concern that although the operator was spelled regularly, the crane did not rest at any time.

In recalculating the motor requirements according to AISE standards, the requirements were in excess of past generally accepted standards. The new motor speed in a travel of 100 or 200 feet and with the high gear ratio required for acceleration, reaches an unsafe speed for free running conditions. To limit this speed by means of an armature shunt is to use a "frill" as a working feature of the control.

The paper stresses briefly the english tests with time versus geared speed as a basis of design. Though not defined, geared speed is the drive speed at rated motor speed. Because of the dual ratings of mill type motors, confusion is encountered, inasmuch as the crane builder utilizes the half-hour or crane rating of motors to coordinate with similar ratings of controller panels.

Present drive specifications indicate a free running speed — a balancing speed — that is obtained under ordinary conditions of operation. As this speed is affected by changes in friction, wear, runway, alignment, and skewing, the writer contends that the specified or working speed should be one to two-tenths less than the balance speed. Reference is made to Richard West's "Electric Traction for Cranes" on the subject. This concept also will tend to balance the oversizing of motors for free running operation. The prospective purchaser or the specifications must state clearly what he desires in a working or a balancing speed. He may get a crane 15 to 20 per cent slower than contemplated although design and computations may be correct.

Mr. Rifkin pointed out that gear ratios of 64 to 1 are indicated for some drives. When compared to 10, 20, and perhaps 30 to 1 normally used, even 45 to 60 were considered ridiculous. High service factors give us too high motor speeds, high gear ratios and dictate the use of armature shunts which in turn destroy some of the designed service factor through dummy loading. A few users already specify compound wound motors for bridge drives. In line with the above problem, this individual wonders whether or not the industry in general is ready for compound motors as a means of satisfactory speed limitation and small gear reductions without sacrificing acceleration and specified speed.

The problem of contactor sizing is another item for coordination. A design requiring the use of a 65-hp, 30-min or 50-hp, 1-hr rated motor utilizes only 38-hp, 1-hr for acceleration and duty cycle. Ordinarily a crane panel of 56 to 110 hp rating would be used with size 3 contactors. However, for a 38-hp, 1-hr load, a size 2 with a continuous rating of 40 hp is indicated. The difference between 38 and 50 hp is then added reserve only in the motor, an added degree of overmotoring reflecting only in free running speed. If the size 2 contactor is used, the customer is penalized by inherently mismatched components only insofar as total capabilities are involved. The horsepower output is assumed limited by the customary 200 per cent accelerating current peaks based on 38 hp and not on 50 hp rated. It is doubtful that the industry will allow such reduction in contactor size from established standards even though there is basic co-ordination.

In view of the insufficiency of the AISE specification regarding performance, the crane builders would like to hear more expressions from members regarding typical performance, especially those on actual working speeds, acceleration, service factor, and top speed of a motor at which an armature shunt or teaser field resistor is required. It must be pointed out that provisions must be made for manipulation of these factors to obtain a working, economic balance that more closely matches the rated size of a motor. Such provisions will level out the differences of those who check a suppliers design against the specification, which is taken too literally as the last word, with little regard for practicality. Wonders can be done with proper balance of requirements.

In short, co-ordination of control and drive equipment must be very closely allied with a balancing of specified speed, acceleration and service factor so that motor speeds, gear ratios and contactor size are in accord with good practices developed over the years. Any further integration of this balancing into the crane specification will help remove the allowable differences in electrical design and assure the purchaser of a crane certain performance characteristics regardless who is the builder. Those of the members who come in contact with bidders realize the cause for variation in motor sizes quoted for a single type crane. A standard specification should remove such a possibility through proper coordination of requirements and we trust that at some time in the future, the standards will be revised to contain this co-ordination.

Dr. J. D. Leitch: A first approximation to the motor size is given by the average horsepower required to accelerate the crane and its load, but before determining this we must first select a rate of acceleration and assume an efficiency for the drive. It is quite possible to select a motor size and a gear ratio such that the wheels will skid, consequently the acceleration rate is limited by the conditions at the rail. A further factor which places a limitation on the rate of acceleration is the comfort of the operator, he cannot be jerked off his feet and feel good about it. The rate of acceleration may not be entirely determined by the skidding of the wheels and the comfort of the operator, but perhaps by the accuracy required in positioning the load. We must first decide upon a rate of acceleration compatible with these limitations.

Having decided that the maximum rate of acceleration is to be 1, 1½, or 2 feet per second, we cannot calculate the average horsepower required to produce such acceleration until we decide upon the gear ratio. If we select 200 fpm as the base speed corresponding to the full load speed of the motor, the gear ratio is settled but we must realize that in making this selection, we may encounter difficulty with excessive free running speed after the crane has been accelerated.

With the gear ratio and the rate of acceleration decided upon we can now determine approximately the average horsepower required to accelerate the crane and its load to base speed or any other speed for that matter, since we know the weight of the crane and its load. The accuracy of this approximation is increased by including the WR^2 of the rotating parts, a procedure that requires some guessing since the WR^2 of the motor armature is not yet known. It must be realized that the knowledge of the average horsepower required for acceleration alone is not sufficient to determine the motor size.

If the crane bridge is going to be called upon to make a lot of short movements, the motor is going to be running most of the time on acceleration current peaks, and we must be sure the motor is sufficiently large to dissipate the heat produced within itself. If the duty cycle of the bridge motion can be estimated in advance, the size of the motor is dictated by the rms current passing through it. This rms current corresponds to the continuous rating of the motor in amperes. This procedure can very easily be carried out in the case of an ore bridge trolley performing a fixed and known duty cycle. It can also be carried out fairly accurately on many bucket and magnet crane applications.

It is quite possible in calculating the motor size on the basis of duty cycle alone to arrive at a size which would demand excessive current during acceleration, a current somewhat greater than the ¼-hr rating of the motor. Such a motor is too small and indicates a very light duty cycle. It is better to choose it on the basis of its ¼ or ½-hr torque rating to meet the acceleration requirements. On the other hand, the same calculations on another crane application may result in motor size considerably in excess of that demanded by the acceleration requirements. Here the duty cycle is severe and the motor must be selected to meet this condition. Failure to do this can only result in overheating of the motor.

If the crane bridge duty cycle is not known, then the selection must be made in terms of experience. For example, one may decide that the duty cycle is quite light, such as may be the case in a power house crane, and select the motor on the basis of its ¼-hr horsepower rating. On the other hand, we may select a motor on its ½-hr rating for general purpose and on its 1-hr rating for more severe service. It should be clearly understood that in making this selection we are, in effect, deciding upon a duty cycle.

A third factor must be considered in selecting the motor size and gear ratio. It often happens that when a motor is chosen large enough to accelerate the crane at the required rate and meet the duty cycle, the free running speed becomes excessive. The equation which determines the free running torque at the motor shaft includes a factor involving friction. This is usually expressed in draw-bar pull per ton of weight and is by no means constant, varying from 10 to 25 lb per ton. We must have more accurate information on this factor if we are going to predict the free running speed. Usually the free running horsepower is but a faction of that required during acceleration and with a series motor, the speed may be higher than that desired.

We have encountered some difficulty with excessive free running speeds, especially on cranes having long runways. Mr. Yagello mentioned the possibility of using compound wound motors in place of series wound motors on bridge drives. I am sure it could be done in many cases to advantage. In a few cases we have resorted to the use of a permanent "teaser field resistor" to give the motor a similar characteristic.

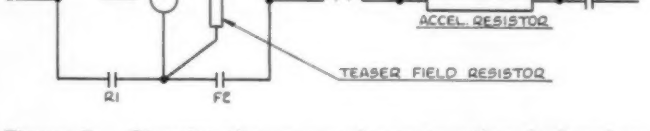

Figure 5 — Circuits shown are the conventional plugging reversing controller normally used on a crane bridge.

Figure 5 shows the main circuits of a conventional plugging reversing controller as used on a crane bridge. A shunt resistor is shown connected permanently across the armature. This is an armature shunt but because of its relatively high ohmic value we prefer to call it a "teaser field resistor." Its ohmic value is about 8E/I where E is line volts and I is full load motor current, and its continuous current rating is about I/7 amperes. The current through this resistor strengthens the field particularly at high speeds. This makes the series motor behave somewhat like a compound motor at high speed as shown by the dotted speed-torque curve of Figure 6.

In some cases we have furnished a contactor to insert the teaser field resistor after the last accelerating contactor closes. The use of a contactor permits a resistor of lower capacity.

Mr. McCrady referred to the need for two steps of plugging in some cases. I agree with him. On very heavy cranes, or on high speed cranes, two steps of plugging give smoother stopping with less abuse on the drive and more comfort to the operator.

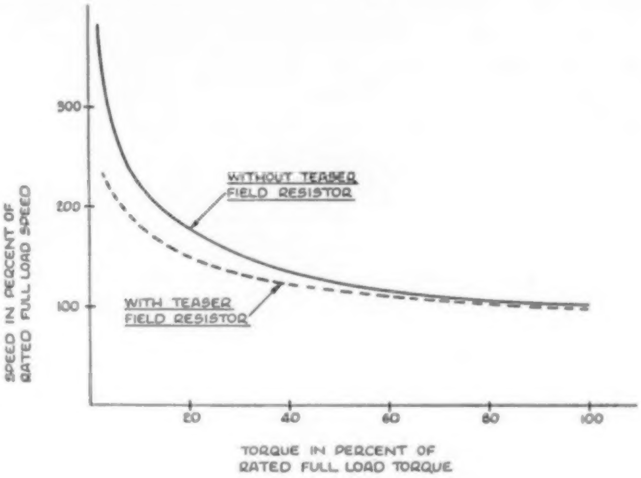

Figure 6 — A teaser field resistor makes a series motor behave a little like a compound motor at high speed.

There is a great need for work such as Mr. McCrady has done, and he is to be congratulated on a timely and instructive paper.

Don R. Gailey: On this question of the application of the motors to crane bridges, there has been a great deal of diligent work done, the control manufacturers have worked long and hard to solve a problem which it seems to me should never have been given to them. We are looking at the symptoms rather than the cause of the question of the high torque requirements, required to accelerate high inertia loads.

The problem has been solved probably more satisfactorily by the street railway people and the people who have designed diesel locomotives, by using either two or maybe four motors starting in series, and then changing to parallel when they approach full speed.

In the steel industry, the use of double armature motors on some of the mills has solved that high acceleration problem.

It seems to me that it could be accomplished, probably at less expense, if a single motor were used at each end of the crane, eliminating the line shaft, also eliminating the necessity for stiffer girders required by the high unbalanced torque, and solving the acceleration problem in much the same way that the machine tool people have done on large planers. Of course, in that case, it is purely a double armature motor.

I am offering that as a suggestion, not from the standpoint of the maintenance man who has to maintain the crane, but from the development standpoint, and from the standpoint of the control manufacturer. It seems to me it could be nicely done on control of the crane.

D. C. McCrady: I do not think the answer is so much that you cannot control a single motor properly, it is more a matter of gear ratio and the way the control is worked out. It is true with series arrangement you have more flexibility. That has been done notably on skip hoists for blast furnaces. However, on cranes, generally speaking, we like to keep it as simple as possible. This is either a single motor or, if necessary, two motors operating in parallel. I think the biggest problem is choice of proper gear ratio based on some kind of a duty cycle or some kind of duty based on usage, as mentioned in the paper, as well as rate of acceleration, and some kind of a speed specification, either balancing speed or speed after ten seconds, or something like that.

R. J. Harry: The item I am particularly anxious to discuss is the design of the control equipment for the bridge motion of an especially hard-worked crane. The crane in mind was one that had a bridge service factor of 1.4. This crane was equipped with 45-hp motor on the bridge, ½ hour rating. The rating of this same motor on the one hour basis is 35 hp. With a bridge service factor of 1.4 it would be necessary to derate this motor to 25 hp which is 1-hr rating of motor divided by service factor or $35/1.4=25$ hp.

The question now arises as to what type of control we should order for this application. In discussing this matter with some of our control manufacturers, we agreed that the contactors on the control should have an ampere rating comparable to the one-hour rating of the motor. The resistor, however, should have the same ohmic value as would be required for a 25-hp mill motor operation and the resistor should be of the same ampere rating as a 35-hp mill type controller.

With this type of controller, the current peaks during the acceleration period would be equivalent to the 25-hp mill rating, and due to the very hard service and almost continuous operation, neither the motor, control, nor resistor would become over-heated.

If a standard 35-hp mill type control were installed on this particular crane, the current inrushes during the acceleration period would be such as to over-heat the resistors and burn up the motor.

It is, therefore, imperative, that on cranes having a very high service factor, due to almost continuous operation, both the controllers and the motor be derated to prevent motor burn-outs due to over-heating.

D. C. McCrady: Several comments have appeared on the use of the half-hour versus the one-hour rating of mill type motors. In my discussion, I happened to choose the one hour rating; all figures, curves and conclusions can be translated to the half hour rating if such were desired as a standard.

Regarding selection of contactor sizes, I submit that this should have some bearing on the crane duty in the sense that I have used the word "duty." With a "standard" duty crane, I suggested an acceleration average current of 172 per cent. For a "heavy" duty crane a current of 124 per cent. Thus, for the same motor horsepower, a smaller sized contactor could be used for the heavy duty crane — heavy duty meaning that the per cent current must be kept lower due to the crane being used more frequently on the resistor, so that the RMS current in the motor will be held to normal.

As Mr. Harry suggests, if the crane is to be designed for "heavy" duty, the allowable acceleration peaks must be lowered — values corresponding to 25 horsepower instead of 45 or 35 horsepower. The resistor current rating must also, as he suggests, correspond to the heavy duty, or in other words 45 or 35 horsepower, depending on the application. I believe it is in this field that some real standardizing could be done, that is, relating resistor ratings to the various duties involved in terms of per cent time on the resistor.

Dr. Leitch suggests denoting the various duties by using the ¼, ½, and 1-hour ratings. This is, of course, one way in which duty can be specified. However, from the standpoint of standardization, I believe that it might be preferable to stick to the one rating — be it half-hour or one-hour — and then specify the duty in a manner such as I suggested, namely, per cent time on the resistor. This would not only specify the motor but also the resistor.

There were also various comments about how difficult it is to specify free running speeds due to variances in friction, and it is for that reason that I suggested the use of "speed after ten seconds" as being a practical measure of the crane speed as well as being one that is virtually free of the friction dilemma. Most cranes that have too high free running speeds are either over-motored or have an incorrect gear ratio for the application involved.

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COKE PLANT AND BLAST FURNACE EXPANSION AT FONTANA

By CLARENCE R. LOHREY
Assistant General Superintendent
Kaiser Steel Corp.
Fontana, Calif.

. . . . many obstacles had to be overcome to set the enviable production records established at the Fontana plant . . . .

▲ THE rapid rate of expansion of the Kaiser Steel Corp. plant at Fontana, Calif., has made operations both interesting and challenging. In its eleven years of existence, this plant has had three major expansion programs which have affected blast furnace and coke oven production and operation. These are: (1) the addition of a seventh open hearth furnace, the second blast furnace and a third battery of coke ovens in 1949; (2) an eighth open hearth furnace and tin mill in 1951, and (3) the addition in 1953 of the ninth open hearth, the third blast furnace and two more batteries of coke ovens.

When production began in 1943 and for the first six years of operations at Kaiser, the steelmaking facilities consisted of six open hearths rated at 185 tons each, one blast furnace with a 25 ft 6 in. hearth to produce 1200 tons of hot metal per day, and two batteries, 45 ovens each, of coke ovens to supply the metallurgical coke requirements. The usual auxiliaries, such as sintering plant, material handling equipment, skullcracker, slag disposal equipment, etc., were all a part of the original plant.

In the beginning, blast furnace ore was obtained from the company owned Vulcan mine located in the Mojave Desert about 200 miles from the plant. Coking coal was supplied from the Sunnyside mines, located in Carbon County, Utah, some 800 miles from Fontana. Tables I and II show a typical analysis of these two raw materials as received at the plant, also the analysis of coke made from the Sunnyside coal.

It will be noted from the physical properties of this coke that it is not a desirable blast furnace material to say the least. One of the first problems confronting the operators was that of finding some means of improving the physical properties of this coke. The solution to this

TABLE I

Sunnyside Coal and Coke Analysis

	H_2O	Volatile matter	Free carbon	Ash	S
Coal, per cent	5.6	38.0	54.9	7.1	1.18
Coke, per cent	....	1.7	86.9	11.4	1.03

Sunnyside Coke Physicals

	ASTM
2-in. Screen, per cent	42.9
2-in. Shatter, per cent	9.2
1-in. Tumbler, per cent	5.7
Apparent gravity	0.82
True gravity	1.81
Porosity, per cent	54.7
Physical fuel value	15.2

TABLE II

Vulcan Ore Analysis — Per Cent — 1944

SiO_2	Al_2O_3	CaO	MgO	P	Mn	Fe	S
5.10	0.88	4.83	3.79	0.043	0.11	51.96	0.985

problem has been described in a paper presented before the Eastern States Blast Furnace and Coke Oven Association by J. H. Thompson in 1945. This paper describes the blending of from 10 to 15 per cent of low-volatile coal from the Oklahoma-Arkansas field, with our Sunnyside coal. This has been our practice since that time; however, successful operations have been obtained using petroleum coke instead of low-volatile coal as a blending agent in the coal mix. Experiments indicate also that char can be used as a substitute for low-volatile coal.

The high sulphur content of the Vulcan ore, often times more than 1.5 per cent indicates that as delivered it was not a particularly desirable blast furnace material. It was found that by a crushing and screening treatment the $-\frac{5}{8}$-in. ore containing a high percentage of the sulphur could be sintered, thereby eliminating approximately 95 per cent of this element. A mixture of the coarse ore ($+\frac{5}{8}$ in.) and the sintered fines made an acceptable economical burden for the blast furnace. As the Vulcan deposit became depleted it became expedient to crush and sinter all the Vulcan ore available, and to supplement the coarse $+\frac{5}{8}$-in. Vulcan with ore from the Utah Construction Co. mines in Utah. Various combinations of these materials made up the iron bearing burden for the blast furnaces until the company's ore deposits at Eagle Mountain were developed for mining in 1948. Since that time all of our blast furnace ore comes from that source. Due to a fairly high sulphur content of Eagle Mountain ore, ranging from 0.3 to 0.8 per cent, this material is also crushed and sized, the fines being sintered to eliminate the greater portion of the sulphur. It should be mentioned that a beneficiation process is presently being installed at our Eagle Mountain Mine.

TABLE III

Blast Furnace Operation — Year 1947

Coke Data

Avg coke ash, per cent	10.9
Avg coke sulphur, per cent	0.96
Avg coke moisture, per cent	2.5
Avg vol matter coal mix, per cent	37.0
Coke physical tests — ASTM, per cent	
Tumbler + 1 in.	20.4
Shatter + 2 in.	37.6
Screen + 4 in.	4.6
+ 2 in.	66.4
Porosity, per cent	54.1
Physical fuel value	31.5

Improvements in blast furnaces and coke oven practices were gradually worked out and by 1947 a very successful and economical operation was obtained. Table III indicates the average quality of coke used for this operation. Table IV represents the blast furnace results using this coke with a burden of 50 per cent Vulcan sinter and 50 per cent of $-2\frac{1}{2}$ Utah ore.

Because of the extremely high freight rate on our coals, Sunnyside 800 miles away and low-volatile coal some 1200 miles distant, it is quite evident that by far the most costly blast furnace raw material is the coke. This means, of course, that it is necessary for economical blast furnace operation at Fontana to maintain a low coke rate per ton of hot metal.

The first expansion program completed in 1949, added along with the seventh open hearth furnace, a second blast furnace and 45 coke ovens. This second blast furnace and also No. 3 blast furnace is identical to No. 1 in size: 25 ft 6-in. hearth, 16 tuyeres, height from hearth bottom to bottom of big bell 90 ft, working volume 41,362 cu ft with a 6-ft working stock line. The planning for this expansion was to build enough coke capacity to produce 2000 tons per day of hot metal, which, of course, is not full blast furnace capacity. Coke requirements were figured on the basis of 20 hour coking time.

TABLE IV

Blast Furnace Operation

Year 1947

Avg daily production, net tons	1259
Avg coke consumption, lb per net ton	1416
Avg flue dust production, lb per net ton	68
Avg iron analysis, per cent	
Silicon	1.04
Sulphur	0.042
Phosphorus	0.374
Manganese	0.78
Slag ratio — bases/acids	0.99
Avg slag volume, lb per net ton	837
Avg wind blown, cfm	58,200
Avg blast pressure, psi	18.1
Avg hot blast temperature	1090
Avg top gas ratio — CO/CO_2	1.72

From work done at other plants and investigations carried out some years ago, it was the opinion of the industry that the optimum coking rate for western coals such as our Sunnyside, was 20 hours. Faster coking time would not produce acceptable metallurgical coke and it was the opinion of many that oven damage would result from such practice.

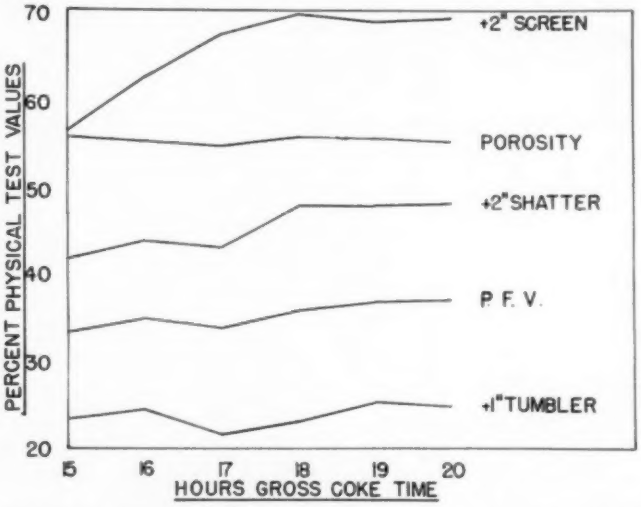

Figure 1 — Curves show effect of coking time on coke quality.

The second expansion program which added the eighth open hearth furnace and tin mill boosted hot metal requirements to full blast furnace capacity and did not provide for more coke ovens. Obviously, it became necessary to supplement our coke production with purchased coke in order to meet the blast furnace requirements. And purchased coke delivered to Fontana from sources available at that time added considerably to our costs. Because of this additional cost it appeared wise to immediately study the possibility of reducing the coking time. If the results of such a study were successful it would save added expense of purchased coke and also have an effect on future expansion plans since a reduction in coking time would result in capital savings on coke oven construction.

Accordingly in April 1950, a group of nine ovens were chosen to conduct preliminary tests. The first test consisted of charging these nine ovens with our normal coal mix, which at that time was 10.5 per cent low-volatile and 89.5 per cent Sunnyside coal. These nine test ovens were operated at coking times ranging from 19 to 15 hours. Samples of each oven were carefully collected, from which chemical and physical tests were made. Figure 1 shows graphically the results of these tests. The most significant trend is found in the screen test. A very decided size deterioration can be seen, but this factor does not become serious up to 16-hr coking time. The appearance of the coke cell structure likewise did not change appreciably at the 16-hr rate. These tests indicated that it would be feasible to continue the experiment.

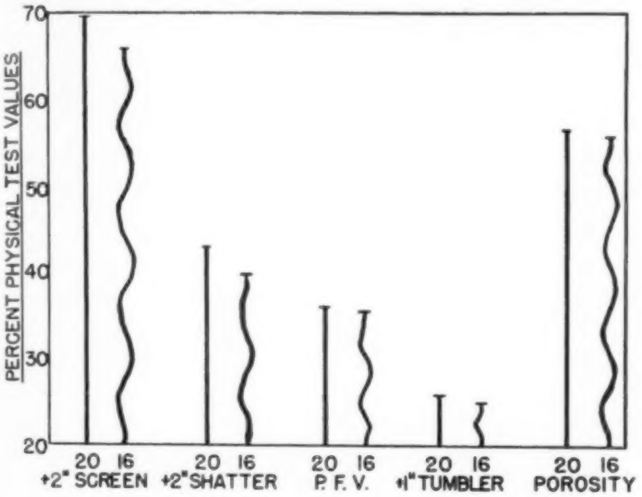

Figure 2 — Bars give a comparison of the results obtained with 16 and 20-hr coking time.

The next step, therefore, was to operate one complete battery of coke ovens at the 16-hr coking rate. This arrangement would provide enough of the 16-hr coke to make a full scale test in one blast furnace, which test, after all, is the only conclusive evidence that can be credited with any degree of finality as far as this type problem is concerned.

This full scale test was made during the month of May, 1950. Again during this test, an intensive job of sampling and data collection was carried out. Figure 2 is a comparison of the physical properties of the two types of coke made during this test period. These results also showed that coke quality deteriorates as the coking time is shortened, however, the slight difference in the physical test values are within the normal limits of day-to-day variance during any normal operating period.

TABLE V

Coking Time vs Blast Furnace Operation

Coking time, hr	**16**	**20**
Hot metal, net tons per day	**1358**	**1319**
Coke rate, lb per net ton	**1402**	**1373**
Slag volume, lb per net ton	**1104**	**1113**
Wind blown, cfm	**64,531**	**60,030**
Flue dust, lb per net ton	**76**	**59**
Coke ash, per cent	**11.1**	**10.6**

During this testing period, constant inspection was made of heating flues, oven walls, in fact all oven brickwork, in order to detect any changes that the faster coking time may cause. And at the end of the test period, each oven of the entire battery was very carefully inspected for any evidence of deterioration in the brickwork.

The only evidence of any pertinent change at all, was a slight addition of wall carbon, but not to the extent of causing any operating troubles. Wall or roof carbon has never been a problem at Fontana and it was considered that a slight carbon deposit would be advantageous rather than detrimental to the oven walls.

Likewise, there were no particularly difficult oven heating problems. It has not been necessary to enrich the blast furnace gas even though the calorific value of this gas is often as low as 80 to 85 Btu per cubic foot. Blast furnace gas is used for oven heating practically 100 per cent of the time.

These same conditions of oven brickwork prevail today after several years of operations at the 16-hr coking rate. Table V shows a comparison of blast furnace performance on 16-hr and on 20-hr coke. It was decided that any differences in the operation of the furnace during these two periods was attributable to differences in operating rate and were not attributable to coke quality to any degree that is serious, if at all.

The success of the program just described has accomplished two things:

1. Purchased coke requirements during much of 1950, 1951 and 1952, were reduced by an average of 280 tons per day. This represents a savings in hot metal costs of approximately one dollar per ton during this period.
2. In planning the latest expansion program which added a third blast furnace and more coking capacity, a reduction in capital expenditure, equivalent to the cost of 55 coke ovens was realized.

Kaiser Steel personnel feel that the use of production level experiments such as the one just described have been effective tools in solving many of our problems.

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

By CLARENCE J. WEBSTER, Fuel Engineer, National Works, United States Steel Corp., McKeesport, Pa.

COMBINATION FUEL FIRING OF BOILER PLANTS

. . . . flexibility and economy have been achieved with the dual firing of blast furnace gas and coal . . . .

▲ WITH the trend in the steel industry toward higher steam pressures and the centralization of plant generating capacity in a few high pressure, high capacity boilers, has come the desirability of having more than one fuel available. Shortage of fuel, even for a very short time, where only one fuel is available, causes plant slowdown and loss of production.

In some cases a primary fuel is chosen and the fuel burning equipment is designed for that fuel with provisions made for handling fuel of another type which will be satisfactory on an emergency stand-by basis.

In most cases, however, new installations are being designed and built to handle primary and secondary fuels in combination with one another.

With few exceptions, steel mill boiler plants have, at their disposal, blast furnace gas which would be bled to atmosphere if not utilized in the boiler plant. Since steam demand and blast furnace gas availability do not correspond and because blast furnace gas storage facilities of adequate capacity are rare, a secondary fuel, that can be easily cut in and taken out of service with load demand, is a necessity. The choice of secondary fuels is largely a matter of availability, transportation, handling and stocking facilities.

At National Works, coal was chosen as the secondary fuel because of the ease of obtaining regular barge shipments and the relatively low cost of equipment to transport coal from an existing coal hoist to the boiler house.

Coal from barges is hoisted directly to a primary crusher which utilizes a magnetic separator for rejection of tramp iron. The primary crusher feeds a series of storage bins, and from there the coal is delivered to storage bins for the individual boilers by a belt conveyor, bucket elevator and a tripper belt conveyor. From the individual bins, located in a building on the boiler house roof, the coal is fed by gravity to the coal scale, rotary vane feeders, and to ball mill pulverizers. The pulverizers, one per boiler, are located on the ground floor of the boiler house. Preheated air from an air preheater is used to classify the pulverized coal as to fineness, and to transport it to the burners.

Blast furnace gas, the primary fuel, is wet washed and precipitator cleaned before entering the boiler house and then distributed from a loop header inside the boiler house to the blast furnace gas burners.

The burners for this installation are the tangential type, suitable for burning separately the fuels already mentioned. There are two blast furnace gas burners and one pulverized coal burner mounted on each corner of the furnace. Through the wind boxes, from the air preheater, is admitted combustion air for the blast furnace gas and secondary combustion air for the coal. The burners fire horizontally and in line with the tangent of small imaginary circles at the center of the furnace. This method of firing creates turbulance in the furnace by impingement of the flame from one burner on that of another and by the swirling action of the gases as they arise in the furnace.

The blast furnace gas is used to the limit of its availability, and upon decrease in supply, as indicated by decreasing header pressure, is limited in flow to the boilers to maintain the header pressure above a safe minimum.

Pulverized coal is fed to the boilers to make up for any deficiency in blast furnace gas. The control equipment is designed to automatically perform this function by cutting back the gas supply to all five boilers as the header pressure approaches a safe minimum, and to start the feeders and pulverizers. Normally only two and rarely more than three boilers are operated with availability controls on the "automatic" setting. The time lag in start-up of the feeder and pulverizer is of such magnitude that the feeder and pulverizer must be run at an idling speed continuously if we are to use the signal generated by the availability control to feed pulverized coal to compensate for lack of blast furnace gas. Rather than idle the coal feeding equipment continuously on all boilers, those in charge of the boiler plant choose to operate only two boilers on complete automatic control as far as availability is concerned. During periods of prolonged low gas pressure, other pulverizers and feeders are started and coal fed by remote manual operation from the boiler panels.

The control circuit used for firing blast furnace gas is a series type system in which a signal, derived from steam header pressure, sets up a demand for blast furnace gas flow and a measurement of total gas flow is used to set up a demand for combustion air flow.

The control circuit for firing pulverized coal is a parallel type system in which a signal, derived from the difference between blast furnace gas flow and blast furnace gas demand, is used to set up a simultaneous demand for coal feed and combustion air flow.

The demand for combustion air for blast furnace gas is added to the demand for combustion air for pulverized coal by a totalizer and is transmitted as a demand for total combustion air flow to an air flow regulator. This signal is opposed by another signal representing actual air flow. The difference between these two signals is used to actuate the governor of the forced draft fan and a forced draft inlet damper.

The furnace draft regulator, operating the governor of the induced draft fan and the induced draft damper, from an impulse set up by furnace pressure, is an entirely separate control system, that is, it is not tied in with the fuel feed or combustion air systems.

The firing of blast furnace gas and pulverized coal has been discussed. For any combination of fuels the problem encountered and the methods of control might be approached in the same manner. Once the air flow demands for individual fuels are determined, the total air flow demand can be added and the forced draft fans and dampers controlled accordingly, to supply this demand.

DISCUSSION

PRESENTED BY

CHARLES S. ALLEN, JR., District Manager, Riley Stoker Corp., Pittsburgh, Pa.

CLARENCE J. WEBSTER, Fuel Engineer, National Works, United States Steel Corp., McKeesport, Pa.

JOHN J. ALEXANDER, Superintendent Electric, Power and Steam, Republic Steel Corp., Cleveland, Ohio

C. E. DUFFY, Fuel Engineer, Bethlehem Steel Co., Sparrows Point, Baltimore, Md.

G. E. REID, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

Charles S. Allen, Jr.: I wonder why you selected direct firing as compared to the bin system?

Clarence J. Webster: I believe that probably one of the big factors in selecting direct firing is safety. Pulverized coal, when stored for any period of time, is very prone to catching on fire. Also we do not have the area available for stocking it as such.

Charles S. Allen, Jr.: As I understand the quesiton, then, you operate direct from the pulverizers to the burners, without the bin system?

Clarence J. Webster: That is right.

Charles S. Allen, Jr.: Approximately what period of time does it take from the pulverizers, to get the coal from the mills on up to the burners?

Clarence J. Webster: The time elapsed from the pulverizers to the burners is a matter of seconds. There is no more than 20 feet of piping involved between the pulverizer and the burner itself.

Member: With reference to the case of bins for storage or pulverizer, we use both. When the author said there was a possibility of those bins getting on fire, they do. We have had that experience very recently with one of our boilers, and believe me, it is nothing to play around with.

You have to be very careful about how you take the coal out of those bins when it does get on fire. But we use both systems, and one of our boilers is fired with two pulverizers, directly to the boiler, and there is no difference in the time that the pulverized coal takes in getting from the raw coal bin to the fire box than it is with the bin fed type.

J. J. Alexander: Have you encountered any problem when burning the minimum quantity of coal? If you are deficient of blast furnace for steam production and require only one ton of coal per hour as an auxiliary fuel, have you experienced difficulties with the pulverizers?

Clarence J. Webster: That problem has not been too serious. We regularly run one ton or less per hour; at one time for a 24-hour period we were down to a total of 0.9 ton of coal for the 24-hour period, and encountered no difficulty.

J. J. Alexander: What is the capacity of that mill?

E. T. Mortson: The pulverizing design is for 6½ tons of coal per hour, approximately 40 per cent of the total capacity of the boiler.

Clarence J. Webster: At one time we believed that 20 per cent of the total capacity of the mill was the minimum rate at which we could fire the boilers, and so set the control on the feeders accordingly. We have since found that we could go to practically zero feed and still idle the mills, so the controls have been reset to feed much less when the demand is low.

J. J. Alexander: When firing at the minimum rate, is the fuel-air ratio of the pulverizer adjusted to provide higher velocity? We have encountered some problem in the operation of a 15-ton per hour pulverizer when trying to burn less than five tons per hour of coal. However, the 15-ton pulverizer is connected to six burners on the boiler. While average velocity of the six burners was adequate, the velocity to two of the burners was too low. It was necessary to increase the air-fuel ratio to provide adequate velocity in each burner pipe.

Clarence J. Webster: At present we are set up to maintain a good air ratio at the absolute minimum of the mill, and we apparently have no difficulties at higher flows.

C. E. Duffy: I wish to ask Mr. Webster several questions:

1. At what steam temperature are boilers operated?
2. When switching from blast furnace gas to oil, or to coal, do you find it difficult to maintain constant steam temperature?
3. Do you use pilot burners?

Clarence J. Webster: We use pilot burners only when we are lighting off the boiler. We do not keep them in continuous operation any more.

Our temperature, runs 900 or 950 F, and then we desuperheat to 750 F in the header leaving the boiler. On all coal, we can operate with our superheat control valves closed, or very nearly so. When we go on blast furnace gas, we do add a considerable quantity of water to bring that steam temperature down to 750 F.

G. E. Reid: I would like to ask Mr. Webster to enlarge a bit on this system control lag he mentioned relative to firing the blast furnace gas. If I understand him correctly, it is necessary to fire some coal even when ample blast furnace gas is available. Is this correct?

Clarence J. Webster: As far as the control system is concerned, it is not necessary to keep any coal on the furnace. There is nothing in our control system that demands that we do.

But at the loads we are carrying, it is quite often necessary to have some coal in addition to the blast furnace gas. We can produce only 175,000 pounds per hour per boiler, when burning all blast furnace gas. Frequently our load demand is somewhat higher, and we have to feed some coal to maintain load.

COMBINATION BAR AND ROD MILL—

LOS ANGELES PLANT

By C. C. BRANDT
Superintendent, Electrical Dept.
Bethlehem Pacific Coast Steel Corp.
Los Angeles, Calif.

and

PHILLIP SCAROLA
Field Engineer
Elliott Co.
Pittsburgh, Pa.

. . . . market conditions on the West Coast have resulted in a demand for unusual flexibility from this mill . . . .

▲ BETHLEHEM PACIFIC'S steelmaking and fabricating facilities in Greater Los Angeles include a steel plant with an annual capacity of 402,000 tons of ingots and a fabricating works with an annual capacity of 21,600 tons of fabricated steel. The steel plant is in Vernon, while the fabricating works is five miles distant, in the Watts section of Los Angeles. Both facilities serve a great variety of industries spread throughout Southern California and Arizona.

Bethlehem Pacific's Los Angeles plant is a direct descendant of the California Industrial Co., a small ironmaking firm organized in the 1880's. After a brief period, the firm changed its name to Los Angeles Iron & Steel Co. and expanded its activities to include manufacture of plates and sheets.

In 1914, the firm became the Southern California Iron & Steel Co. and construction was started on its first open hearth furnace, billet mills and bar mills.

In 1922 the plant was moved to its present site in Vernon, and in 1930 it was acquired by Bethlehem Steel Co.

The plant continued to enlarge under Bethlehem ownership and following World War II it became one of the three steelmaking plants of the newly formed Bethlehem Pacific Coast Steel Corp.

Today Bethlehem Pacific's Los Angeles plant is an efficient, compact operation with balanced steelmaking and finishing facilities. Its operations include modern electric steelmaking furnaces, high speed rolling mills, a wire mill, a bolt and nut manufacturing department, a fabricated reinforcing bar department and laboratories.

The steelmaking facilities now include one 50-ton and two 75-ton electric furnaces which have replaced the three 50-ton open hearth furnaces.

Included in an expansion program started in 1948 was a 10-in. continuous bar and rod mill, which is the subject of this paper. There are many rod mills located in the steel mills of the U.S.A. and each is different from the others in some respects. This is partially due to the product mix expected to be rolled on the mill and the range of products to be rolled.

This particular mill was designed as an all-purpose mill to produce a wide variety of shapes and sizes to meet the trade requirements in the area. A total of 21 horizontal stands are employed, driven by nine adjustable-speed d-c motors. Flexibility of the 10-in. mill's output is shown in Table I.

TABLE I

Rod	**7/32**	**to 47/64 in. diam**
Rounds	**3/8**	**to 1¼ in. diam**
Squares	**11/32**	**to 1 in.**
Nut flats	**3/8**	**to ¾ in.**
Flats	**¼ x ¾**	**to ½ x 2½ in.**
Strip	**⅛ x ¾**	**to 2½ in.**
R.E.A.L.S.	**3/16 x 1¼**	**to ½ x 2½ in.**
Parabolic spring sections	**1¾**	**to 2½ in.**
Reinforcing bar	**3/8**	**to 1 in.**
Angles	**¾ x ¾**	**to 1 x 1 in.**

The general layout of this mill is shown in Figure 1 and an explanatory one line diagram of rolling combinations is shown in Figure 2.

Billets are supplied to the mill in 30-ft lengths, 2½-in. square; however, 4-in. square billets can also be used. A saving of 8 hours roll-change time per month has been effected by using 2½ × 2½-in. billets instead of 4 × 4-in. billets on larger size products, thus reducing the total number of required roll set-ups on the roughing mill to two. Descaling is accomplished in the roughing

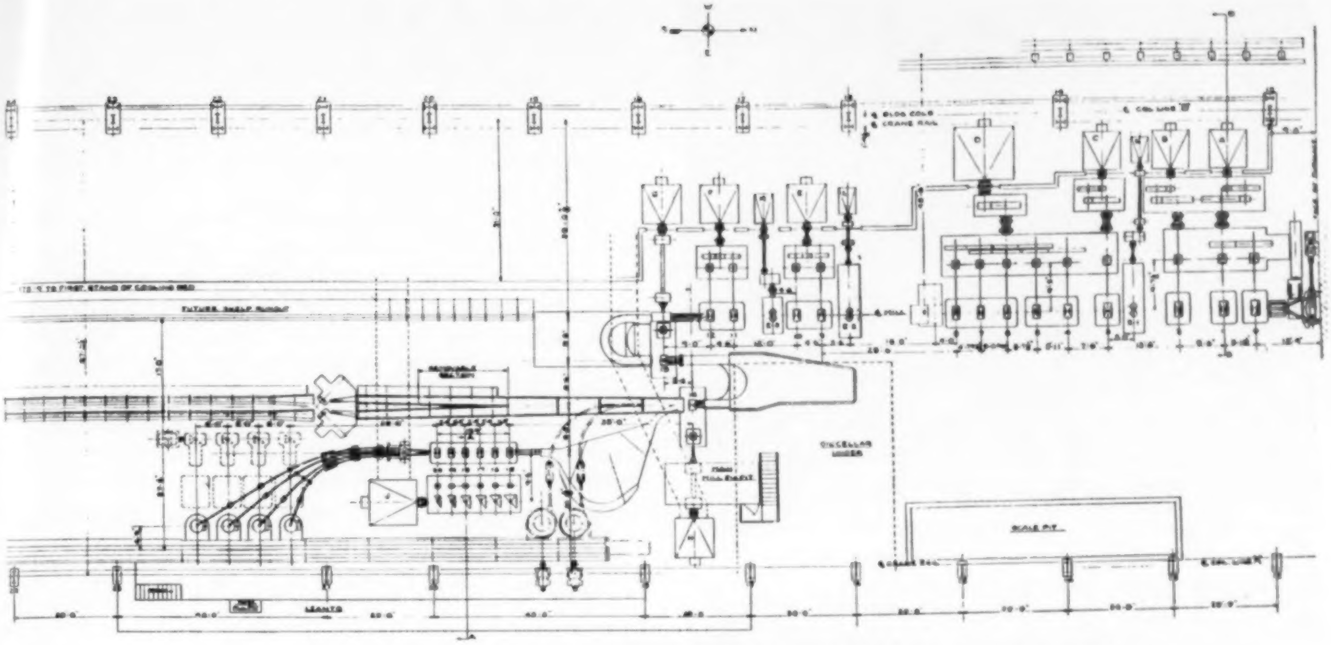


Figure 1 — Layout shows 10-in. rod mill at Bethlehem Pacific's Los Angeles Plant.

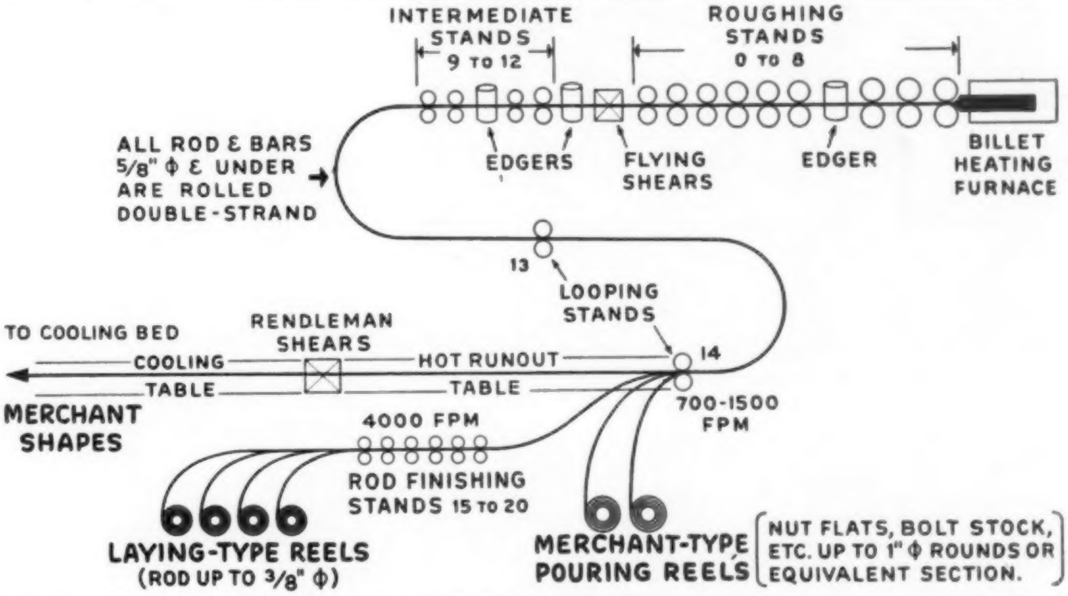

INTERMEDIATE STANDS 9 TO 12
ROUGHING STANDS 0 TO 8
ALL ROD & BARS 5/8" ϕ & UNDER ARE ROLLED DOUBLE-STRAND
EDGERS
FLYING SHEARS
EDGER
BILLET HEATING FURNACE
13
LOOPING STANDS
14
TO COOLING BED
RENDLEMAN SHEARS
COOLING TABLE
HOT RUNOUT TABLE
MERCHANT SHAPES
4000 FPM
700-1500 FPM
ROD FINISHING STANDS 15 TO 20
LAYING-TYPE REELS (ROD UP TO 3/8" ϕ)
MERCHANT-TYPE POURING REELS
NUT FLATS, BOLT STOCK, ETC. UP TO 1" ϕ ROUNDS OR EQUIVALENT SECTION.

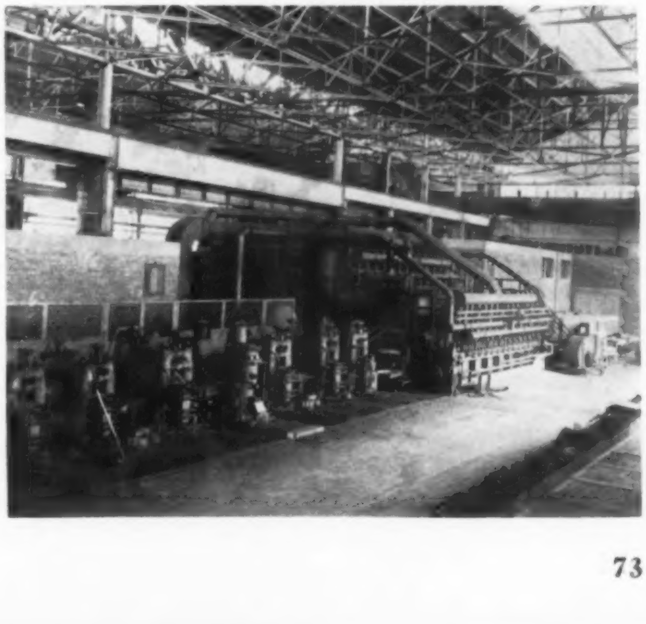
Figure 2—A number of rolling combinations are used on the mill.

mill by four 14-gpm spray nozzles directing 600-psi water on bars between stands 0 and 1, and 1 and 2. Billets are produced on a 32-in. reversing blooming and a 22-in. 3-high, billet mill, which also supply billets for a 12-in. bar mill adjacent to the 10-in. mill.

The furnace preceding the roughing stands is of the side-charge, side-discharge type, with an effective heating area of 32 × 45-ft (Figure 3). It is divided into a primary and a secondary heating zone, both equipped with 14 burners, fired either by fuel oil or natural gas. Temperature, air-fuel ratio and pressure are controlled automatically.

All rods $\frac{7}{32}$ in. through $\frac{13}{32}$ in. and bars $\frac{7}{16}$ in. diameter and under are rolled double-strand. For double-strand rolling, the heated billets are entered into either of the passes in the first stand (Figure 4). A manually operated toggle-shear, arranged for either single or double-strand operation is mounted on the entering side of the first roll. The roughing mill consists of four stands, 0 to 3 inclusive, having 16-in. diameter rolls and five stands,

Figure 3 — Heating furnace has an effective heating area of 32 x 45 ft.



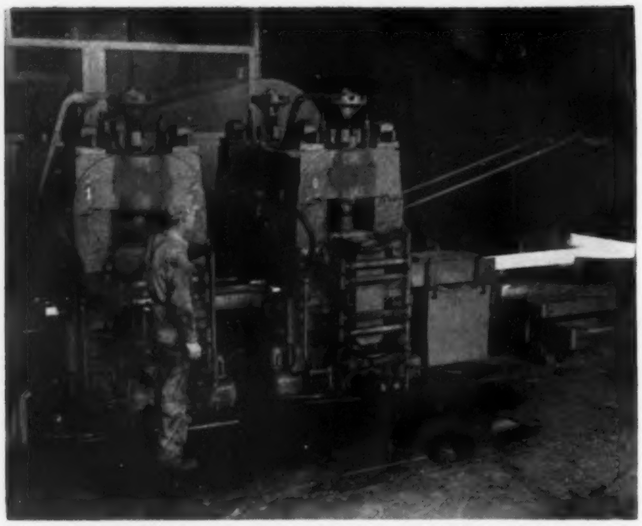


Figure 4 — Billets may be entered into either of the passes in the first stand for double-strand rolling.

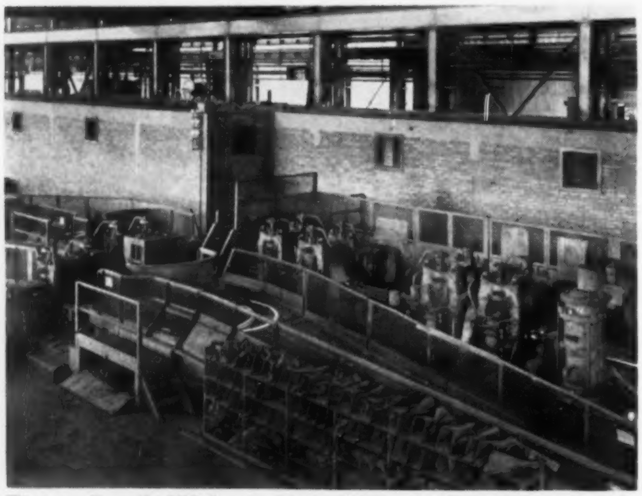


Figure 5 — A 500-hp motor drives intermediate stands Number 9 and 10.

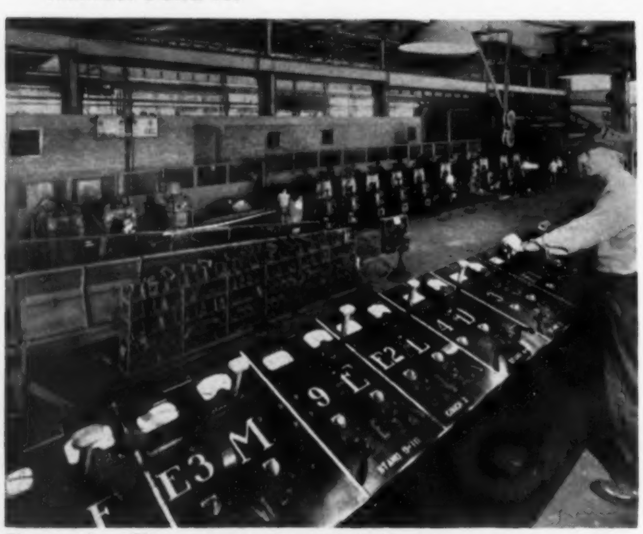


Figure 6 — The operator's pulpit has a clear view of the mill.

4 to 8 inclusive, having $14\frac{17}{32}$-in. diameter rolls, all driven through gear-reduction units. Stands 0 and 1 are driven by a single 300-hp motor, while stands 2 and 3 are driven by separate 300-hp motors. Stands 4 through 8 are driven by a single 1250-hp motor.

An air-operated manually controlled flying shear, maximum cutting speed 650 to 700 fpm, is located after the last roughing stand for the selective cropping of the front ends of bars. It can be moved out of the line when bars not requiring cropping are rolled.

Intermediate mill stands 9 and 10 are driven by a 500-hp motor, as are stands 11 and 12 (Figure 5). Roll diameter is 13-in.

The 12-in. finishing stands 13 and 14 are direct driven, each by 350-hp motors.

Three repeaters are available for the automatic looping of rod and merchant bar sections. The first two, of the 180-degree type, are located ahead of the first repeater-connecting stand; the third, of the forward-running type, follows the bar-finishing stand. Mechanically operated repeaters actuated by photoelectric eyes with electronic timers are used when rolling flats, nut stock and small angles, to more effectively control the entering of bars into stands No. 13 and No. 14. An electrically actuated double-strand snap shear is located ahead of stand No. 14.

The operators control the speeds of all mill motors from an elevated pulpit located opposite the intermediate stands. Figure 6 shows a clear view of the roughing mill from the operator's pulpit.

All sections other than rods under $\frac{7}{16}$ in. are finished in No. 14 bar-finishing stand at speeds ranging from 700 to 1800 fpm. Depending on customer's requirements these sections are delivered either to coilers or on to the 170-ft runout table to the double cooling bed. Two rotary disc-type flying shears in the runout tables, synchronized to the delivery speed of the mill, cut the bars into hot bed lengths. Actuated by movable electric eyes on the hot bed, the shears cut any desired length to within a tolerance of one foot.

The double hot bed (Figure 7) of sloping construction has a maximum run-in roll speed of 2500 fpm. Its total length is 360 feet, of which 240 feet is equipped to pack anneal spring flats. Bars are kicked off the run-in rolls by two paddle-type kickoff mechanisms operated by solenoid-controlled air cylinders. Front ends of bars on bed can be spotted within three feet of a desired point by positioning the electric eye which actuates the kickoff. The bed is equipped for either automatic or manual control by pushbuttons, the operator's pulpit being located at the delivery end of the bed adjacent to the two motor-driven shears. Operation of shuffle bars, cold runout tables, shears, shear tables, shear gages and shear table kick-off is electrically controlled by a shearman on each side of the bed.

Certain special sections, such as nut flats and bolt rounds, are also finished in No. 14 stand and delivered to the two 46-in. diameter merchant-type pouring reels. Speed of the reel-drive motor is manually adjusted so that indicating tachometer for the reel drive matches the No. 14 stand indicating tachometer.

The reels are alternately engaged and disengaged to a common drive by a clutch arrangement so that one reel can be unloaded while the other reel is coiling. In discharging a coil the reel bottom plate raises above the pins and tilts in one motion, allowing the coil to slide onto a chain conveyor.

Wire rod is finished in the six rod finishing stands, through a bevel-gear drive unit by a 1250-hp d-c motor. The speed out of stand No. 20 for maximum mill output is 4500 fpm.

Rod is delivered to four laying-type reels by specially designed connecting pipes, each equipped with a set of spray nozzles and water eliminators. Thus the temperature of the rods can be controlled before they enter the reels, minimizing grain growth and scale formation. The 600-lb coils, 46-in. outside diameter, are then transferred horizontally to a chain conveyor by means of stripper and push-off drives interlocked so that the coils are pushed when the reel guide pins are down and the conveyor is in the correct position. The chain conveyor, which is an extension of the conveyor from the pouring reels, slopes upwards above mill floor elevation where the coils are picked up by an overhead hook conveyor and carried over a coil inspection and tying platform.

Coils are carried up an inclined hook conveyor for 600 feet, (Figure 8) then across the mill building for 350 feet to the end of the conveyor. The coils are automatically tripped off the conveyor into a chute which discharges into special narrow-gage coil cars, which are automatically positioned the width of one coil by a chain-driven car indexer. The loaded cars are weighed and then delivered by narrow-gage diesel locomotive to the wire mill coil storage area.

When the mill is rolling rods, the inspector cuts samples, gages for size, and inspects for surface defects. Along with this he twist-tests the smaller sizes of rod for surface defect inspection. On larger rods a magnetic particle test is made to detect defects. In addition, cold-heading quality material is given an upset test. Hot bed samples are cut at shears, gaged, and inspected for surface defects. The higher quality products are also given a magnetic particle test. Hardness tests are run on spring steel.

All mill stands have phenolic-type bearings lubricated by water from the plant circulating water system. Phenolic thrust rings are used on stands 0 through 12, while stands 13 through 20 are equipped with double-row ball-thrust bearings.

Mill scale is carried by water to a settling basin opposite the roughing mill, where it is removed by clam shell and overhead crane. The water is returned to the central pumping station and cooling tower by three 2000 gpm vertically driven deep-well pumps located below the mill floor.

Conventional brass guides are used throughout the rod finishing stands; cast iron guides in the remainder of the mill. Special roller twister guides are used ahead of the repeaters when rolling nut flats, spring flats and other special sizes.

The central systems for the lubrication of all main drive gear units and pinion stands are located in cellars below the mill floor. System "A," which supplies stands 0 through 14, has a capacity of 10,000 gallons, circulating rate of 287 gpm and 35 psi normal line pressure while system "B," which supplies stands 15 through 20 and the laying reels, has a capacity of 4500 gallons, 112 gpm flow and 35 psi pressure.

Full-flow scraper-type filters clean the oil continuously. Centrifuging of the oil is done based on tests every six months for acidity, viscosity, moisture, foreign materials, and additive content. Both storage tanks are equipped with heaters and system "B" with a cooler to maintain temperature at 100 F. A howler and indicating lights located opposite the mill pulpit operate on low oil pressure at any one of four places.

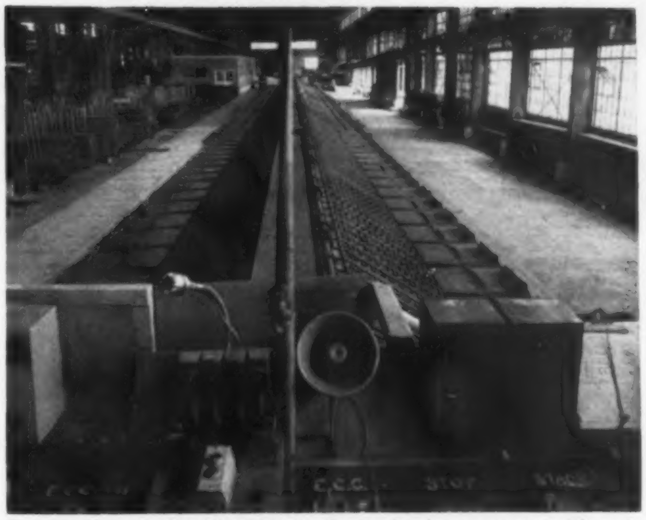


Figure 7 — A double hot bed of sloping construction is used on the mill.

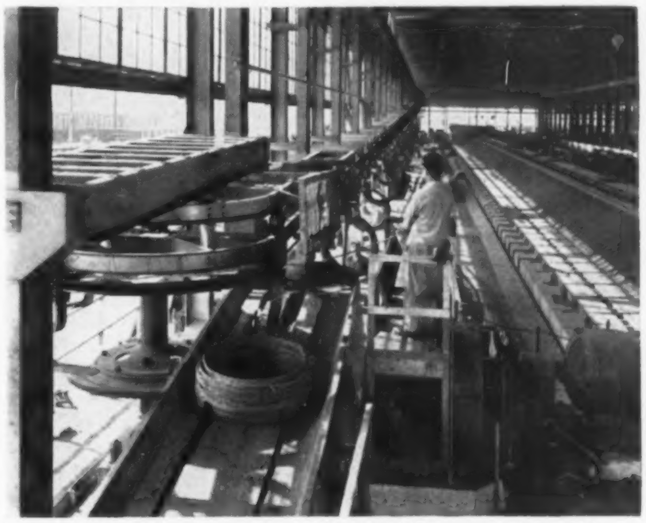


Figure 8 — A hook conveyor is used to carry the coils up an incline.

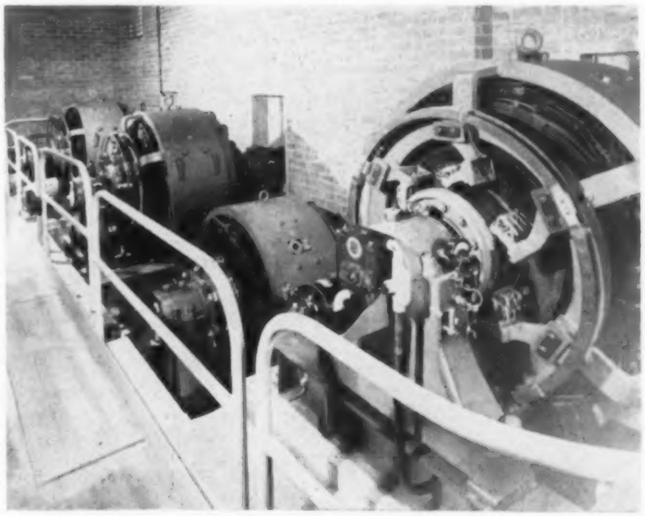


Figure 9 — All main drive motors are designed especially for steel mill service.

The incoming 6600-volt, 3-phase, 60-cycle power supply is distributed through indoor metal-clad vertical-lift switchgear located in the motor room. The 6600-volt power is used to drive the 4400-hp and 2800-hp synchronous motors of the main motor-generator sets. The switchgear assembly consists of seven cubicles including

TABLE II

Stand No.	Motor	Hp	Motor rpm	Gear ratio	Maximum roll, rpm	Rod speed, fpm	
						Minimum	Maximum
0	A	300	250/900	32.184	27.98	32.7	117
1	..	....	....	22.940	39.2	45.6	164
2	B	300	250/900	18.077	49.8	58.2	208
3	C	300	250/900	14.424	62.41	72.2	261
4	D	1250	150/450	4.650	96.8	119.	354
5	..	....	....	3.138	143.3	174.	520
6	..	....	....	2.189	205.5	252.	750
7	..	....	....	1.634	275.2	336.	1005
8	..	....	....	1.257	357.5	435.	1305
9	E	500	300/900	2.379	378.3	428.	1285
10	..	....	......	1.897	474.5	536.	1615
11	F	500	300/900	1.731	520.	590.	1770
12	..	....	......	1.423	632.5	730.	2140
13	G	350	225/625	1.000	625.	708.	1950
14	H	350	225/625	1.000	625.	708.	1950
15	J	1250	450/750	1.018	737.	1150.	1930
16	..	....	....	0.844	889.	1395.	2440
17	..	....	....	0.750	1000.	1570.	2760
18	..	....	....	0.658	1139.	1780.	3120
19	..	....	....	0.556	1326.	2080.	3680
20	..	....	....	0.496	1512.	2570.	4140
E-1	K	150	250/1000	10.97	91.15	......	....
E-2	L	150	250/1000	1.93	516.8	......	....
E-3	M	100	250/1000	1.87	534.8	......	....

one incoming line unit, two motor running units, two vertical reactor units, and two vertical reactor breaker units. The motor running units each incorporate an air-blast circuit breaker rated 500,000 kva interrupting capacity, and the vertical reactor breaker units each include a vertical reactor breaker rated 250,000 kva interrupting capacity.

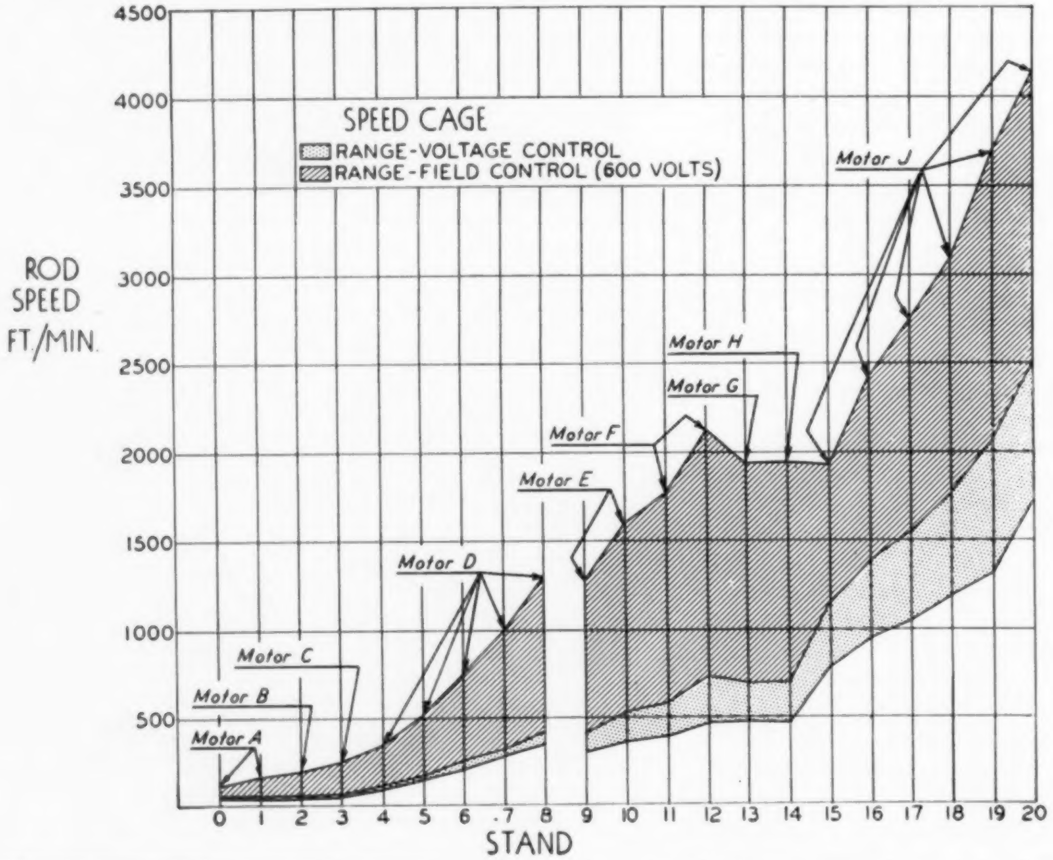


Figure 10 — Speed curve for mill is shown on this diagram.

Two motor-generator sets furnish the power to the adjustable-voltage main-drive motors. Motor-generator set No. 1 consists of one 2000-kw, 360-rpm d-c generator and one 2800-hp, 0.8-power factor synchronous motor supplying power to motors A, B, C, D and K. Motor-generator set No. 2 consists of two 1500-kw, 514-rpm d-c generators and one 4400-hp, 0.8 power factor synchronous motor supplying power to motors E, F, G, H, J, L and M and runout table motor-generator set.

The generator panels located opposite the a-c switchgear were designed for operation on either a split bus or on a common bus. While the common bus has not been used for actual rolling schedules, it has proved very convenient during roll changes to turn over any of the mill stands from one generator, freeing the other set for normal inspection and maintenance.

The adjustable-voltage control for the mill drives located in the motor room opposite the main drive motors is non-reversing dynamic braking control. All panels are equipped with recording ammeters, motor-operated rheostat, master switches for operating the motors from the motor room for testing purposes, and field-reversing switches.

All the main drive motors are especially designed for steel mill service. They are of heavy-duty steel mill-type construction, (Figure 9) with two pedestal-type bearings mounted on a fabricated steel base. All motors are stabilized shunt wound, 600 volts, d-c, separately excited from a 250-volt exciter.

Each motor has visual bearing temperature indicators with relay contacts, overspeed limit switch, and space heaters and tachometer generator. Speed regulation, no load to full load and full load to no load, is held within 1½ per cent through the use of series exciters.

All main-drive motors which are located in the main motor room, as well as motors H and J located in the mill area proper, are supplied with clean air from a non-recirculating ventilating system. The air is cleaned by three automatic self-cleaning electric precipitator-type cleaning units. Capacity of the system is 137,000 cfm; cleaning efficiency is 85 per cent.

The cleaned air is carried to separate forced-ventilation enclosure on the rear ends of motors located in the motor room. Motors H and J, located out in the mill area, are provided with enclosures on both ends.

The ratings of the main drive motors driving stands No. 0 through No. 20, together with the speed of the rolls, is shown in Table II, based on a generator voltage of 600.

From these speeds, the speed curve shown in Figure 10 was compiled. This curve shows the usual slopes for the roughing, intermediate and looping stands with the dip in top speed in the looping stands.

From these curves, it is evident that the top speeds of the finishing stands can be increased without creating a bottleneck in the roughing and intermediate stands.

It has been possible to raise the rod mill delivery speed from its rated 4000 fpm to 4500, by increasing the d-c mill motor voltage from 600 to 675 volts, allowing the motor speeds to increase proportionately to as much as 12½ per cent above their nameplate rating. Top speed when delivering to the hot bed out of stand No. 14 is 1800 fpm.

The fact that d-c motors drop in speed when a load is suddenly applied is well known and it is not the intent of this paper to discuss the theory and effects of impact speed drops. Several well written papers on this subject have been presented before the AISE in recent years that can be referred to for further study. When selecting main-drive motors for modern continuous rod mills it is customary to specify limitations on the speed regulation of the main-drive motors, and it is desirable to design the motors with as low an impact speed drop as practical. The moment of inertia, the resistance and reactance of the armature circuit are all factors affecting the impact drop, recovery time and speed regulation of the motor.

Several oscillograms were taken of this mill to see what the impact drops, recovery and speed regulation of the motors are under actual operating conditions. Figure 11 is a copy of an oscillogram of motor H rated 350 hp, 225/625 rpm driving the finishing stand No. 14. It can be noted from these curves that the maximum speed drop occurs at 0.24 seconds after the bar hits the mill. At this instant the current has built up to a value of 124 per cent full load current, and the speed has dropped to 93.4 per cent of the operating speed of 328 rpm representing an impact drop of 6.6 per cent with 106 per cent load. The speed and current reach a steady state condition at 0.7 seconds after the bar enters the mill, and at this point the speed has recovered to 98.7 per cent of the no-load speed, a drop in speed at slightly better than full load of 1.3 per cent.

Figure 12 shows the speed and current curves of motor E rated 500 hp 300/900 rpm driving two stands No. 9 and No. 10. As can be expected the impact drops are about half that shown on Figure 11 since approximately 50 per cent load is being applied at each stand.

Exact operation of the rotary flying shear is required in order to obtain uniform selected lengths on the hot

Figure 11 — Maximum speed drop is only about 6 per cent at 124 per cent load. Curve is for motor H at stand 14 rated 350 hp, 225/625 rpm with full load current of 472 amp and operating speed of 328 rpm.

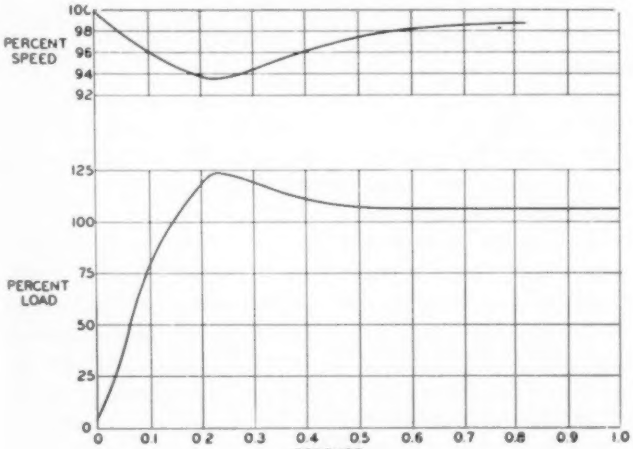
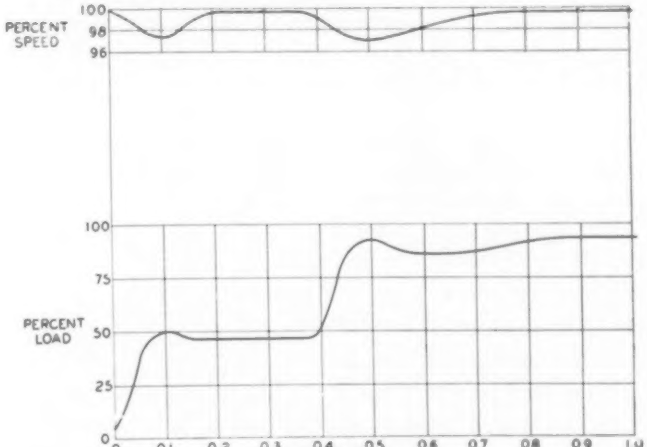


Figure 12 — Speed drop for motor E which drives stands 9 and 10 is given in this sketch. Motor is rated 500 hp, 300/900 rpm with full load current of 673 amp and operating speed of 310 rpm.



bed and a high product yield. Another requirement for a good operation is the elimination of cuts less than 30 feet on the last bar of a slightly overweight billet. Short lengths pick up speed more rapidly on the runout table, overtaking the bar ahead, which is likely to cause a cobble when both bars are kicked off simultaneously at the hot bed.

The bars are cut when a solenoid hydraulically operated spout swings the bar into the two rotating blades which are mounted in a vertical plane at an angle of 45-degrees to the runout roll line.

When the mill was placed in operation, the shear spout solenoid circuit was actuated when the front end of the bars touched an insulated roll located ahead of the hot bed and connected to an electronic relay. Cutting lengths of bars were adjusted by the hot bed operator through calibrated settings on an electronic timer. A slight adjustment in mill speed or a change in supply voltage to the timer introduced an error in the cutting lengths up to 10 feet in a 300-ft bar.

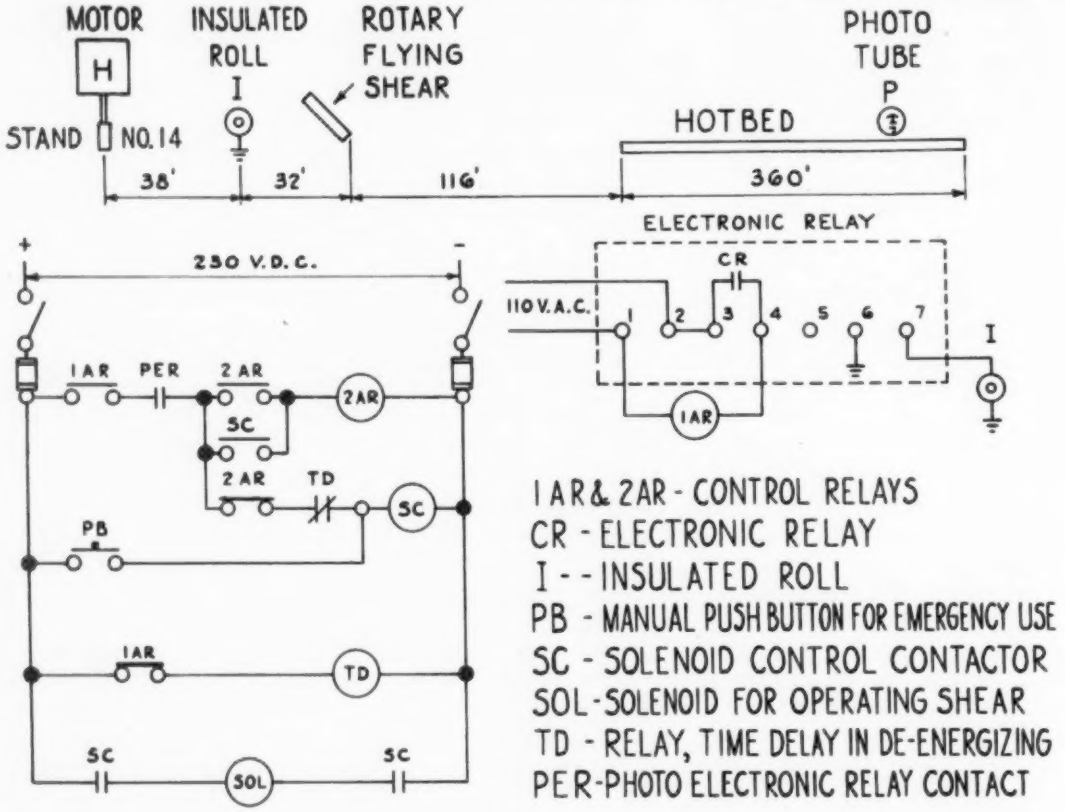


Figure 13 — Present schematic wiring diagram for shear control circuit.

Accuracy of cutting lengths to within one foot has been achieved by the installation of water-cooled photoelectric eyes which can be placed at any position along the hot bed for picking up the signal for instantaneous cutting, eliminating the need for a timer. Both water outlet receptacles and photoelectric relay receptacles are provided every 50 feet along the bed for the photo-tube holders, equipped with 30-foot water hoses and electric cords. Figure 13 shows present schematic wiring diagram of the shear control circuit and the relative positions of equipment.

Insulated roll "B" is located ahead of the shear to prevent lengths less than 30 feet from being cut off the last cut bar from a billet. Relay 1AR, which is energized through the electronic relay, whenever a bar is on the insulated roll, opens circuit to time delay relay TD and sets up circuit for photoelectric relay PER to operate solenoid control relay SC as soon as front end of bar reaches the photoelectric eye. The No. 930 photoelectric tube is sensitive enough to operate the photoelectric relay directly from the light of bars as small as $\frac{3}{8}$-in. diameter or $\frac{1}{8} \times 1$-in. strip. An asbestos curtain is used around the photo-tube holders to keep outside light reflection from causing false operations.

The laying reels are arranged in a group of four and are driven by an adjustable-speed, separately excited, shunt-wound d-c motor in which the required speed range is secured by both shunt field and armature-voltage control. The reel-drive motor is supplied with an auxiliary motor-generator set in conjunction with a rotating regulator to maintain a synchronous tie relationship with the rod-finishing stand motor (J). A reel pulpit has been provided for the control of the reels, strippers, push-offs, and rod conveyors.

Stripper and push-off for the four laying reels are driven by eight $7\frac{1}{2}$-hp standardized mill-type motors. Each is equipped with a solenoid-operated brake and geared limit switch.

There are many rod mills or combination rod and bar mills installed in the U.S.A. and so far as we can determine, no two are alike. The market demands and rolling facilities of other mills in the plants determine what products these rod and bar mills have to produce.

This particular mill was designed to produce a wide range of products as shown in the introduction to this paper. As a proof of its success, the record month shows a total of 51 sizes of products were produced for a total of 16,784 tons at an average productive rate of 24 tons per hour. The record rolling for an 8-hr turn for $\frac{7}{32}$-in. rod is 246 tons or 30.7 tons per hour, and for $\frac{5}{8}$-in. diameter concrete reinforcing bar 56 tons per hour.

Trends in Blast Furnace Linings

By HOBART M. KRANER, Ceramic Engineer, Research Department, Bethlehem Steel Co., Bethlehem, Pa.

. . . . increasing demands by the blast furnace operator push to the limit the ingenuity of the ceramic engineer and manufacturer . . . .

▲A number of progress reports on the developments of blast furnace linings have recently been written by competent men in the industry. A discussion of the trend of blast furnace designs might be considered to be a summary of this progress. Although blast furnace production certainly has kept pace with ever-expanding steel production, this has been accomplished by bold expansion of furnace sizes and by improvements to many other pieces of accessory equipment and to furnace operations. Refractories, as one item, have been improved over the years. We are fortunate in having excellent fire clays for fire brick. These clays have responded well to technological improvements in processing refractories and have given favorable results in our furnaces.

There are operators among us who well remember the use of hand-made brick in the small furnaces of their time. The campaigns on these linings lasted for only a half million tons, which was considered a very good performance. Hand-made brick were soft or "punky" and had high porosities; they were poorly shaped, probably disintegrated badly in carbon monoxide and dissolved readily in slag and alkali. Being soft and "punky" they certainly did not withstand abrasion. Stiff mud brick which were produced next were made of plastic fire clay and produced a fine-grained brick to withstand abrasion; but, although these fine-grained brick represented an improvement over hand-made brick, they were not effective according to present standards and requirements.

Dry-pressed brick came next. They were better shaped and resulted in improved bricklaying jobs. They, too, were fired in periodic kilns, with a wide range of temperatures. This was not conducive to uniformity in properties. The product often had as much as 24 per cent and as little as 15 per cent of their volume in pore space. A 24 per cent porosity in the brick meant a high potential shrinkage and considerable instability in the furnace lining during use. Dry pressing under reduced pressure (vacuum pressing) decreased the porosity and helped somewhat to lower the range of porosity. However, even this method produced a brick which had 18 to 20 per cent of its volume in porosity, which meant 6 to 7 per cent lineal shrinkage when the brick was subjected to vitrifying temperatures during the campaign, particularly in the furnace hearth. Hearths made of these brick soon loosened and the brick floated out. Salamanders often extended deep into the concrete foundation, as shown in Figure 1. Refractories of this type are still available.

Hard-firing of certain types of clays gives a product impermeable to water and of low "apparent" porosity. Actually, 20 per cent of the volume could be pore space, which does not change the potential shrinkage in the furnace during use. If used in a hot part of the furnace, it is generally pyroplastic. This is especially true in the hearth.

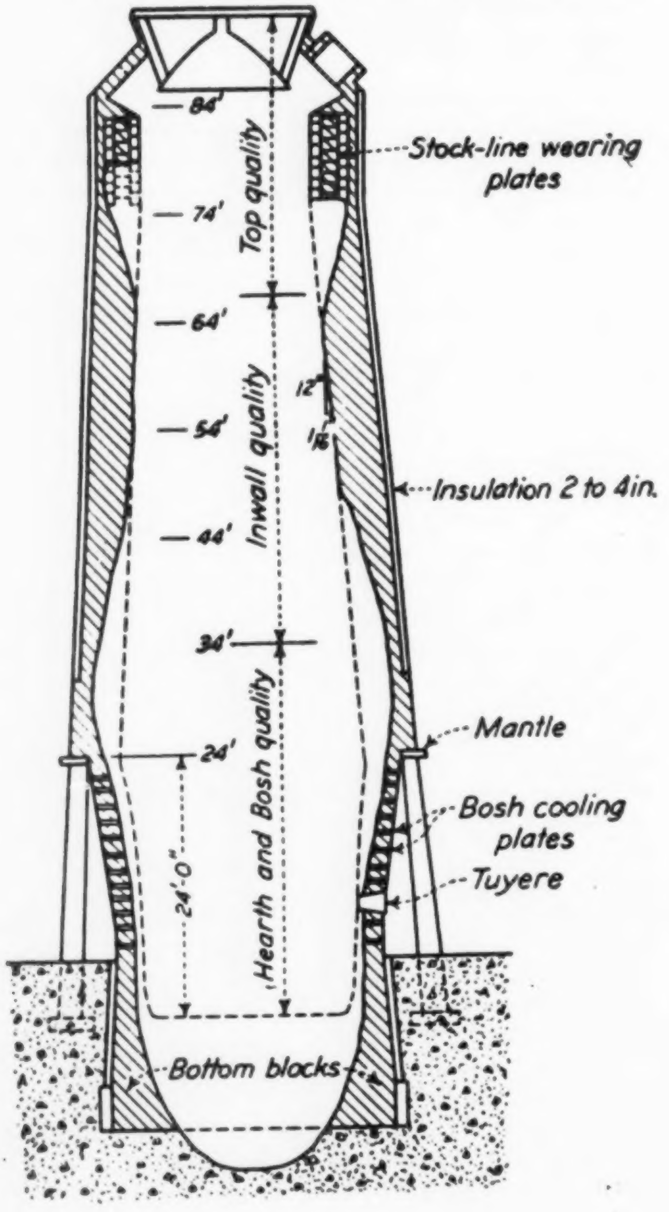
Porcelain when manufactured enters the kiln with 30 per cent of its volume as pore space. Firing produces vitrification and no porosity in the final product. It is possible to approach this in some fire clay products. Some fire clays tend to fire to a dense structure with a large proportion of sealed pores, others fire to a low total porosity. The latter are preferred for refractories going into locations where the brick must undergo pressure of molten metal at high temperatures. Missouri super-duty brick are made of this type of clay. Laboratory tests show that the increase in density and impermeability produced by hard-firing improves the resistance of the refractory to slag and alkali attack.

Hard-fired super-duty and hard-fired high-duty clay refractory linings have been in use in iron blast furnace linings since 1939 when both of these were tried in one furnace as a zoned lining. Since that time such linings, as they became available, have been used in increasing number. One manufacturer provided the first, complete super-duty lining in 1940 and since 1950 several other suppliers have come into the market. Like any other new development there have been some questionable results, but from the experience of the writer in analyzing the results of about 39 hard-fired and super-duty linings and partial linings it appears that both are here to stay. If there have been revelations of shortcomings of heat-shock resistance, it is proper to remind alarmists that the shortcomings may be largely in the methods of using refractories. Examples are available which amply demonstrate abuse to refractories during blow-in. Research brings these abuses to light. Progress will eliminate them.

The English do not have fire clays such as we possess, but as they do have pure white-burning refractory kaolin or china clays, they have made several linings with brick made of this type of clay for stack use. Results have not progressed far enough to present the overall picture of the use of this type of brick. Preliminary indications, however, are favorable, in spite of the high cost of these brick. The product is quite pure, refractory, and does not disintegrate in carbon monoxide. It has a high porosity which could mean high potential shrinkage, but this may be offset by sufficient refractoriness to resist the temperature satisfactorily without shrinkage. This remains to be seen.

Carbon in the proper location offers hope of extending the life of the furnace, particularly in hearth walls, by preventing breakouts which have plagued many operators where hot slag makes vicious attacks on most other refractories. The English were stimulated to extensive use of carbon by such a situation. They were either more fortuitous or thorough in their designs, for, recognizing carbon as a good conductor of heat they put the carbon against the water-cooling without insulating with clay brick as we did. Their practice freezes the metal at a considerable distance from the outer shell of the furnace. Ours allowed metal to pass through the wall to the clay brick. The use of clay brick in the hearth wall may be practiced if the carbon is placed against the coolers with the clay brick on the hot side. It has been found that in this way the carbon cools the clay brick wall and extends the life of the clay brick by so doing.

Figure 1 — Salamanders have been known to extend deep into the concrete foundations as illustrated in this sketch reported by W. R. McLain in the Bulletin of the American Ceramic Society, Vol. 19, 1940, pp 62-68.



As an expedient, we used large blocks of anthracite coal made available to us from electrode manufacture. The English, by circumstance, had at their disposal only small blocks made of coke. They have found that the small blocks are readily adaptable to changes in furnace design. They have developed corrugated blocks for hearths and have used carbon in normal construction to the top of the furnace. The latter is now regarded to be unsatisfactory and they do not recommend carbon above the mantle.

HEARTH REFRACTORIES

As has been stated, the use of carbon blocks in the hearth bottom has not been favorable. A number of installations with bottom slabs of carbon were unsuccessful as the slabs disappeared during use. Whether this was due to solubility in iron, as the English have claimed, or whether the blocks floated out, is in doubt. As thermal studies will show, the temperatures on both sides of carbon slabs are relatively the same and this allows metal to exist in a molten condition below them. This contributes to the belief that the blocks floated out. Anchoring by tongue and grooves and dowelling has been resorted to.

High bulk density super-duty brick with low potential heat shrinkage have done a good job in the hearth bottom. In several cases where such furnaces have been blown out, only 2½ courses of 18-in. blocks of this material had disappeared in campaigns of almost 2,000,000 tons. See Figure 2.

The use of carbon in hearth side walls provides best resistance to slag attack in this area. The combination of carbon side walls with high bulk density brick of adequate refractoriness in the bottom appears to be a happy combination for a prolonged life, and generally satisfactory hearth design. This design appears to make the large salamander which often extended into the concrete pad, or spectacular break-outs of the furnace, things of the past. In Figure 1 McLain shows a typical hearth ware line of the era prior to 1940.

The proper height to which carbon should be used above the hearth jacket of the furnace has not been settled, but carbon in this area is being watched with interest. A study of current installations shows that the trend is upward and that the use of carbon in the tuyere section is now common.

The protection of carbon tapholes is a perennial problem. Needless to say, carbon will be oxidized by water in the tap hole clay. In operation, the hot carbon is protected either by dry tap hole clay from previous closings or by a permanent brick lining. Here there are still two schools of thought, one demanding a clay brick-lined tap hole on the blow-in, the other seemingly not needing one.

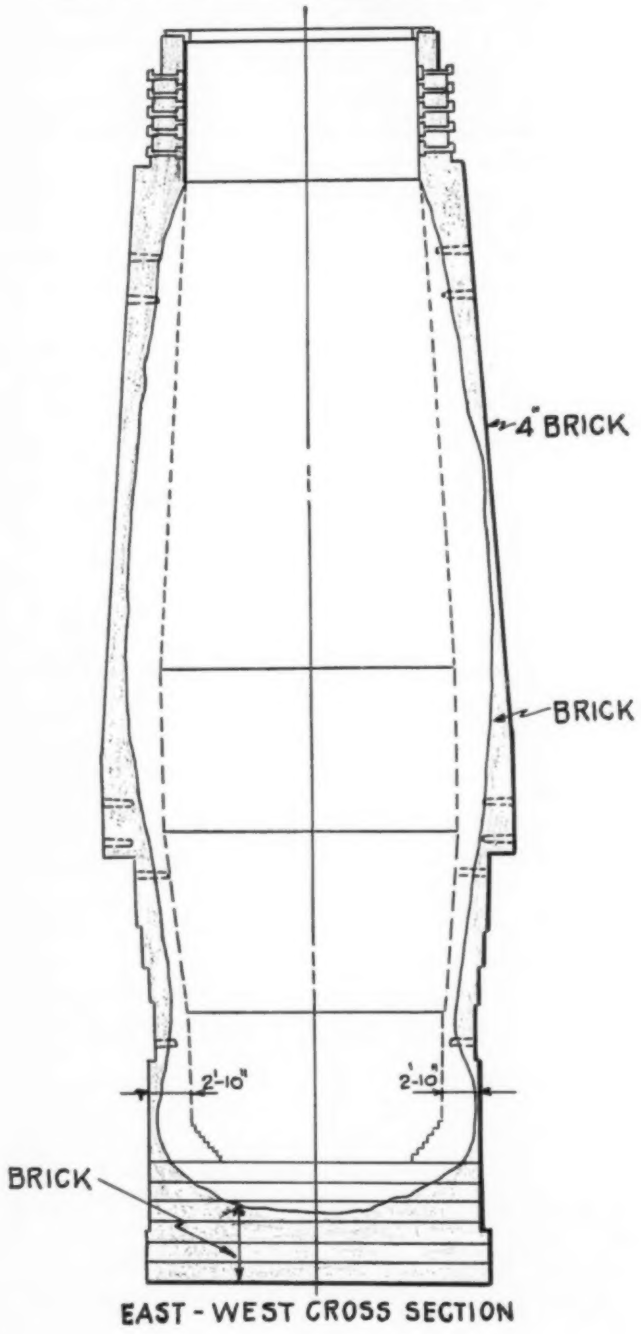
A protection wall of second-quality brick is required to protect carbon brick during drying and blow-in of the furnace. These should be bonded with air-setting cement as a positive pressure in this part of the furnace may cause oxidation of the carbon.

Recent temperature measurements in clay brick walls have revealed blow-in heating rates of 1000 F or more in a few minutes, which is destructive to clay refractories. The use of 9-in. of second-quality brick serves as a protective lining against oxidation of hearth walls. It will also protect the tuyere breast and bosh brick against excessive heating rates.

BOSH REFRACTORIES

As the bosh is so extensively water-cooled there are those who seem to find no need for life improvement in clay bosh refractories; however, the carbon bosh may provide smoother operation. English practice and experience with one furnace in this country have established confidence in externally-cooled carbon bosh linings. Recent installation of another carbon bosh here will be watched with interest.

Figure 2 — Very little wear has been observed in some hearth bottoms as shown in this sketch of a furnace blown out after almost 2,000,000 tons.



STACK REFRACTORIES

Stack refractories are subject to carbon deposition and disintegration, which manifest themselves in a soft zone between the shell and the working face of the lining. This also results in a weakened zone under the wear plate section, (see Figure 1) and is often responsible for weakening of the wear plate section to such extent that the armored section disappears. Alkali attack is severe in the middle section of the stack. Hard-firing has generally resulted in elimination of the weaknesses resulting from carbon deposition and has improved resistance to alkali attack. Examination of several of these linings has revealed only 3 in. loss of wall thickness in stockline area in 1,700,000-ton campaigns. Although laboratory results show that super-duty brick have improved resistance to alkali attack, the wear in this zone due to alkali attack is still severe. We must look further for lining material for this zone which will more nearly meet the need.

The English found that carbon would not stand oxidation above the mantle. One experience here with carbon in the throat gave the same result. At least one furnace in this country, however, has carbon above the mantle. The results will be watched with interest.

Carbon, the selection and hard-firing of special clays, and close specifications as to sizing, tend to increase costs, but with other costs rising as they have done, we can ill afford to continue with the ordinary quality refractories of two decades ago. In fact, increased demands for superior material are needed to offset the added cost of other details of relining or rebuilding. Fifteen years ago a philosophy was advanced that in order to gain quality, one could double the cost of a brick in a lining if only 100,000 additional tons could be gained in the campaign as this would be sufficient to return the added investment. Then, as now, the cost of the refractories for the lining is approximately only 10 per cent of the total cost of the installation. We cannot afford to risk 90 per cent of the cost by an ill chosen 10 per cent which is so vital to the life of the entire job.

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DISCUSSION

JOHN J. HAZEL, Ceramic Engineer, Metallurgical Dept., Republic Steel Corp., Cleveland, Ohio.
B. L. DORSEY, Maintenance Dept., Jones & Laughlin Steel Corp., Pittsburgh, Pa.
V. J. NOLAN, Manager, Industrial Sales, National Carbon Division, Union Carbide & Carbon Corp., New York, N. Y.

John J. Hazel: There is no question about the fact that the trend is back to the use of more carbon refractories in the blast furnace. This is a change from a few years ago when, with the exception of one steel company, everyone was vetoing the use of carbon. Why, after so many installations of carbon, did the trend suddenly turn away from carbon? Here again may be only a personal opinion that after a few premature failures, the conclusions were too hasty that this material was unsuitable for use in the blast furnace. I shall quote a few figures on the tonnage made in carbon hearths at the present time in the 22 furnaces of Republic Steel Corp. Of the 22 furnaces, 18 have carbon hearths, of which nine have over a million tons of production. Two of the other four furnaces are scheduled for relines with carbon hearths, with the remaining two furnaces due for relining in 1954 or 55. These furnaces will have carbon hearths. In Republic the carbon hearth is a reality.

Space is too limited to discuss the various carbon hearth designs in use. Mr. Kraner points out the trend in design in use in his company. I feel there are many good designs in use at the present time. I cannot point out one design and make the emphatic statement, "This is the one and only design for a number of furnaces." The answer may be yes, for one particular furnace. There are still many factors, operating, mechanical, location and others, that dictate the design and method of construction.

In discussing stack refractories it was gratifying to notice that Mr. Kraner did not use the often misquoted terms "cone 18 and cone 23 burn" blast furnace refractories. The terms "regular burn or high fired" more nearly cover the classification of these newer types of blast furnace refractories. Some of the same alarmists who condemned carbon were very eager to jump on the wagon and condemn the high fired brick after a few questionable results on this type of refractory. Republic has a number of these so-called high fired linings. Sure, we have had a few hot spots here and there, but, on the other hand, many of these furnaces have broken daily records, monthly records, and yearly records. Many of them will, no doubt, break their record lining life. I believe this again is more than a trend.

There is still a great need for better refractories, because no matter how hard the steel industry ceramic engineers work with the refractories manufacturers to bring out improved or better refractories, the demand for tonnage, and the demand for speed which often results in improper blowing in of the furnace will drive the ever-present agressive blast furnace operator to find ways to burn it out. Therefore it will be necessary to continue our efforts along the line of improving blast furnace refractories as well as construction practice in lining blast furnaces. The best material in use today may be unsuitable tomorrow.

B. L. Dorsey: Mr. Kraner has presented a comprehensive paper on "Trends in Blast Furnace Linings," summing up experiences and what is being done with super duty firebrick and carbon linings. I want to inject another type of refractory that is currently being used for hearth walls in some blast furnace linings. It is the low porosity high alumina brick. Experience with this refractory has not been sufficient to draw any conclusions at this time but they should not be overlooked. Further, when operational practices result in higher temperatures in the zone immediately above the mantle, this type of refractory with its higher refractoriness, volume stability and resistance to carbon disintegration merits consideration.

The bosh has never been a refractory problem as Mr. Kraner has stated. However, where shapes are used, they have not been easy for the manufacturer to make, and if standard sizes of brick are used, considerable skill and time is required for their proper installation. A bosh refractory that will eliminate the need for the water-cooled bosh plates, as we now know them, should be desirable if a gain in time is made during construction as well as a smoother operation of the furnace. The carbon bosh externally water cooled will be given more consideration as experience in American practice is gained.

The packing material used between the refractory lining of the stack and the shell has also been given considerable attention in recent years. Here the trend is toward a firmer material with little consideration, if any, given to its insulation value.

Member: We are most indebted to Mr. Kraner for an excellent summary on blast furnace design and refractory development to date, and the merits derived from the use of higher fired refractories in blast furnace liners.

It might be interesting to this group, in view of Mr. Kraner's comment, to know that linings, other than standard high-heat-duty fire clay brick are at present installed in 135 out of 263 blast furnaces in the United States. Of these, 42 are complete linings, and 93 are zone or section linings in the blast furnace.

It has been definitely demonstrated that the higher fired brick show an improvement in the section directly under the stock line armor, where carbon monoxide disintegration has been a factor, which was well outlined by Mr. Kraner.

We feel that the refractories industry is making a continued study on the improvement of product, with a view to better and longer compaigns.

V. J. Nolan: Carbon linings above the mantle are relatively new in application and it is my understanding that there are two or three furnaces in England still running with carbon stack linings extending some 30 feet above the mantle. The blast furnace operators in the United States have done a few things somewhat different than the English operators, and it is entirely possible that the few differences in construction will make quite a difference in length of life of the stack lining. Carbon stack linings in the United States are in direct contact with the steel shell, and in this way the cooling water on the shell should be much more effective than if a heat dam is created between the lining material and the shell.

ELECTRIC SYSTEMS FOR MAIN DRIVES

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. . . . advancements in the engineering of electrical mill equipment not only increase production, but give better control and quality . . . .

▲ ROLLING mill drives are continuing to increase in horsepower. These increases are the result of efforts to obtain greater output from each mill in the rolling process from the reversing slabbing mill to the strip temper mill, and from the blooming mill to the rod mill. The increase in production is being obtained by operating at higher speeds and by better utilization of the rolling mill itself. Both factors increase drive horsepower since they both result in the drive doing more work.

Today's main drive systems also feature increased and improved automation and instrumentation. The higher operating speeds require these features and the better utilization of the mill is obtained through them. Improvements in quality control and per cent yield further justify them. They can be built into the system for a few per cent of the total investment. They remain on guard monitoring performance during the lifetime of the equipment and undoubtedly pay for themselves many times.

As the horsepower and automation have increased so has the electrical content of the installation and with it interest in the electric drive system. Today's rolling mill is an immense installation requiring a capital investment of many millions of dollars and capable of tremendous production. The mill itself is supplied by one manufacturer, the electric equipment by another. Each has several points of manufacture. These equipments are not assembled together until they reach the installation. The equipment must fit together easily and it must not be necessary to perform many months of testing in order to obtain satisfactory performance. Everything about the modern rolling mill indicates the necessity for adequate and correct system engineering.

SYSTEM ENGINEERING

In today's terminology the main drive electric system includes everything electric associated with the blooming mill, the hot strip finishing mill, the cold reduction mill or whatever the mill being studied. For a d-c drive the electric system includes the a-c to d-c conversion equipment, the main drive motors and all the regulators, control, switchgear, etc. After all, each is important to the successful operation of the mill and should be selected and engineered with the overall system requirements in mind.

Ratings and design characteristics of motors and mill rotating parts are important. Each type of drive requires different specifications of characteristics for the d-c generator or mercury arc rectifier. The inherent characteristics of the main drive control system must be compatible with the characteristics of the process. In short, the modern rolling mill requires that the system be engineered to perform as a system, rather than independently as motors, generators or rectifiers and control.

Deficiencies in the characteristics of the rotating machines cannot be expected to be made up by the feedback control or regulating systems. The modern high speed tandem cold tinplate mill could not be expected to perform as it does if the moments of inertia of motor plus mill did not have the proper relationship to each other and to the motor rating; or, if the motors were not designed to obtain a specified speed regulation pattern from the first to the last stand. Nor would it operate as it does if the generators were not designed with characteristics especially for the application.

The modern feedback control, or regulating system, makes it possible to take advantage of these refinements built into the rotating equipment. First, output can be increased by raising the rolling speed because the regulating system is continuously monitoring performance and quickly perceives and corrects for undesired variations in output even at very high rolling speeds. Second, unit product cost is reduced because the regulating system automatically and continuously makes the required adjustments without shutting down or requiring the concentrated attention of operators to correct for the changing condition. Third, the feedback control system improves quality because it holds the process within very close limits by continuously checking performance against a reference, or standard, and automatically corrects for any deviation from the desired condition.

The trend to higher rolling speeds and the desire to obtain better utilization of rolling mills both lead to increased automatic control of variables, and unavoidably make the electric systems more involved. Any additional function to be performed cannot but add another piece of equipment, which must be properly correlated with the other parts of the system. Industry recognizes and accepts this inescapable fact.

However, the automation is being extended even to maintenance. A recently developed electronic memory type trouble locator is now being provided on main drive equipments. This new tool pinpoints in a fraction of a second the cause of even intermittent troubles. The drive may even be restarted without losing the indication.

Relatively few industrial users are in a position to design a fairly complicated electric system for a modern rolling mill. They seldom have the intimate knowledge of the several electrical products comprising the system, or the experience of combining and coordinating these products together. Hence, the metal rolling industry must rely to a greater extent than ever before upon the engineers of the electrical manufacturers to tackle this coordinating job. The number of requests to assist in studying rolling mill operations and to discuss quality control problems is steadily on the increase. Both the metal rolling industry and electrical application engineers recognize the benefits of such work in making it possible to blend the electric equipment with the process itself. Only when these two parts are successfully joined together do we get a workable, satisfactory overall system.

There is probably no industry where electric equipment is so woven into industry processes as in the steel industry. Electrical maintenance will become more complicated as new equipments are installed. However, the cost per unit output will be decreased because of the improvements obtained. Changes in economic and technological considerations make worth while a review of the requirements of rolling mills and an evaluation of the electric system features best suited to fulfill today's production, labor, and quality control requirements.

CONSTANT SPEED OR ADJUSTABLE SPEED

The universal adjustable speed drive is still the d-c motor. In spite of numerous efforts for many years, electrical engineers have not as yet invented a better system. Industry now depends to a greater extent than ever before on d-c drives, particularly the adjustable voltage type. While the field of adjustable voltage drives is constantly being enlarged, there are a number of main roll drives continuing to be powered by constant speed a-c motors. When there is no problem of speed matching between stands and frequent reversals are not required, a constant speed motor is not only the least expensive but the most proper. If metal is in only one stand at a time, there is no speed matching problem. If metal is in several stands driven by a single motor, then of course, speeds must be matched by keeping mill roll settings to requisite diameters relative to the train as a whole. Close mechanical adjustments are necessary, and depending upon the range of products to be produced, an economic point is reached where awkwardness and expense of mechanical adjustment and quality control are offset by changing to independent or grouped drives using adjustable speed motors.

Constant Speed Drives—To determine whether a constant speed mill should be driven by a synchronous or a wound rotor induction motor, we should first know all about the mill and second, have a clear understanding of motor characteristics and advantages and disadvantages. In addition, we must look at the associated electrical control equipment available and with the motor comprising the complete electric system.

A synchronous motor must have maximum torque rating sufficient to carry all usual load peaks, and reflects these peaks directly into the power system. On the other hand, a wound rotor induction motor with a flywheel will slow down on load peaks, permitting the flywheel to contribute energy and shielding the motor and the power system from the full magnitude of the load. On a load of low average value with high peaks of short duration, a synchronous motor not only must have a higher maximum torque rating than the induction motor, but also a higher continuous rating, as the rms heating of the unequalized load is greater than that of the equalized load. This does not necessarily mean the synchronous drive is more expensive, but it does means that more care must be used in designating the synchronous motor characteristics. If a load beyond its maximum torque is applied to a synchronous motor, the motor will pull out of step and will probably stall. Under similar conditions, a wound rotor motor with flywheel will ride through a severe load peak of short duration by slowing down to an abnormally low speed, thereby extracting more energy from the flywheel.

In general, flywheel equalization is impractical for peak loads of much more than five seconds duration, for unless the flywheel is abnormally large, the motor will be carrying practically all the load at the end of this interval. For such application, the less expensive synchronous motor should be used unless the power system requires that the loads be eased on and off gradually.

If frequent starting, and starting torque are required, then the wound rotor induction motor has definite advantages as compared to the synchronous motor. Because the wound rotor motor has an adjustable external resistance in its rotor circuit, maximum torque can be obtained at standstill. By removing resistance as the speed increases, this maximum torque can be maintained throughout the entire acceleration period. Also, the large losses associated with accelerating and decelerating the drive are dissipated external to the wound rotor induction motor, but within the rotor of the synchronous machine. Because of this internal heating, the number of starts of which a synchronous motor is capable, is extremely limited.

Briefly, the advantages and disadvantages of the synchronous motor as compared with the wound rotor induction motor may be summarized as follows:

Synchronous drive advantages:

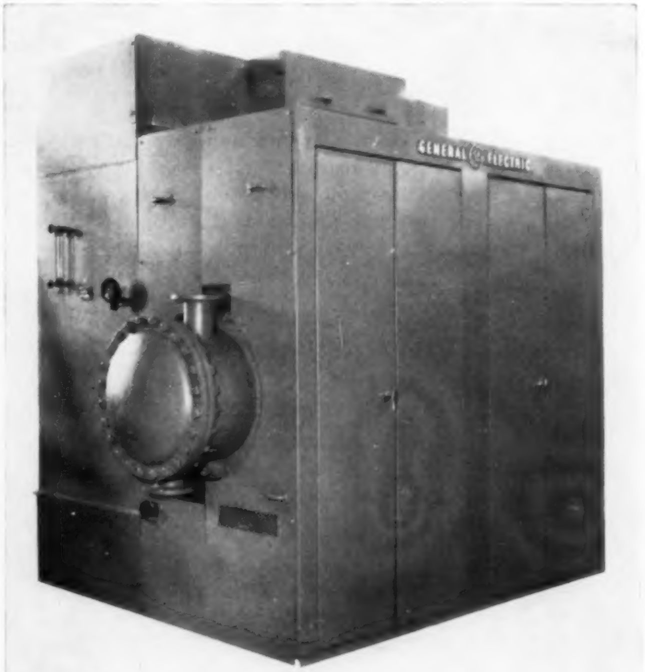
1. Ability to correct power factor.
2. Higher efficiency.
3. Maximum torque varies directly instead of as the square of voltage.
4. Good power factor for low speed direct connected drives.
5. Large air gap.
6. Lower cost.

Synchronous drive disadvantages:

1. Poor starting characteristics (poor torque efficiency).
2. Inability to take advantage of flywheel.

Liquid Slip Regulators—The advantages of both synchronous and wound rotor induction drives are enhanced through the proper use of available electric control systems. With the round rotor induction motor, these operating characteristics are obtained through the use of secondary control. The secondary control may consist of a liquid slip regulator, or a magnetic equipment composed of contactors and resistors. The slip regulator is used for sizes of 2500 hp and above, since in these sizes it is cheaper than the magnetic control and provides a better degree of load equalization.

Figure 1 — Liquid slip regulator for wound rotor induction motor flywheel drive may be obtained in newly redesigned factory assembled construction.



The slip regulator is a liquid rheostat with associated load regulating control that is used to adjust the resistance in the secondary circuit of the wound rotor induction motor so as to control its speed when the load current rises above a pre-set value. For simplicity of control, a standard two stage rotating amplifier functions both as the regulating element and as the power supply to a d-c torque motor. The action of the regulating system is such that it causes the electrodes of the liquid rheostat to separate, increasing the resistance in the rotor circuit of the main motor, thus causing it to slow down and allowing the flywheel to carry the load increase. When the load decreases the electrodes approach each other, causing the speed of the drive to increase again, thereby restoring the energy to the flywheel.

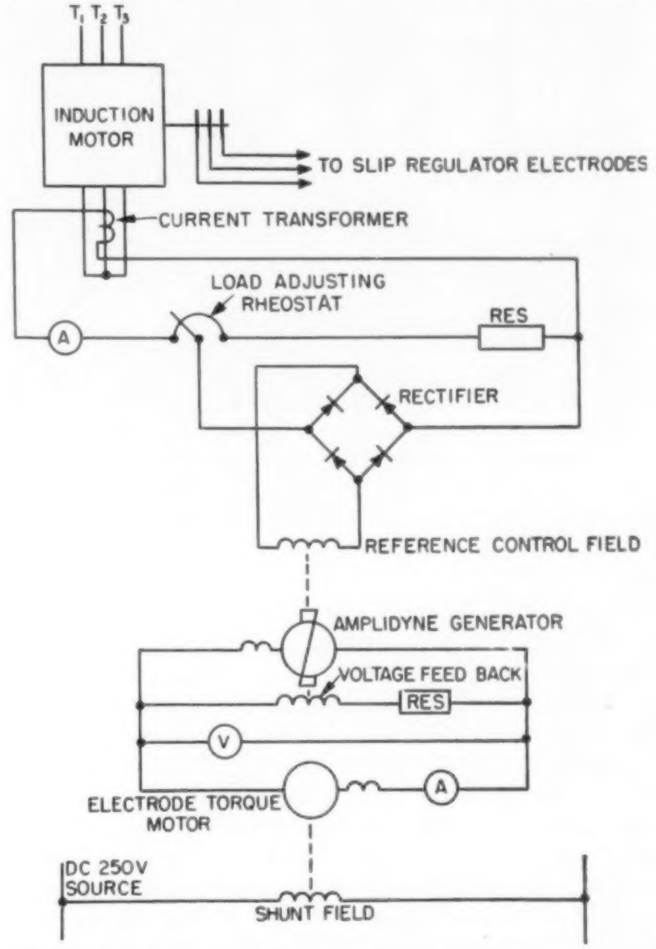


Figure 2 — For simplicity, the electric regulating control system used on the liquid slip regulator utilizes a standard two stage rotating amplifier as regulating element and d-c supply for electrode torque motor.

New liquid slip regulators feature a more compact design requiring less floor space and weighing less. Units may be obtained in complete factory assembled construction to reduce installation time and expense.

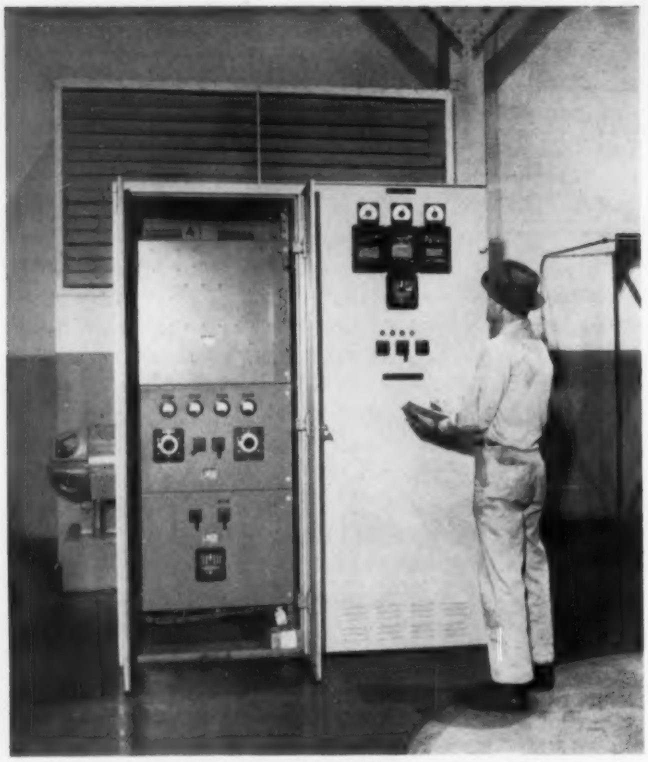


Figure 3 — Synchronous drive excitation regulating equipment at left is used to minimize a-c bus voltage variations on a tandem cold sheet mill installation. Synchronous motor field application metal-clad unit is at right.

A complete re-design has resulted in a more efficient heat transfer system utilizing smaller electrodes, better cooled through forced recirculation of electrolyte. Operating mechanism and regulating system have been re-designed for optium speed of response.

The general construction consists of a steel tank in which the three cells and three sets of electrodes are assembled. The cells are steel, welded to shape, closed at the bottom and rubber lined. The stationary electrodes in the bottom of the cells are therefore insulated from one another except through conducting space in the electrolyte between the lower and upper electrodes. The upper electrodes are joined together by suspension rods, conducting the current to the neutral cross channel which joins all three rods together. This assembly is suspended on cables around pulleys at the top of the mechanism and counter-balanced to a certain extent by a common counter-weight. The electrode torque motor supplies the rest of the force to raise the electrodes under the influence of the regulating control system.

On some mill drives, reduced speed is required to permit the metal to enter the rolls successfully and therefore must be obtained under no load conditions, as well as under load. It should be noted that the liquid slip regulator provides a range of speed under load, and that the no load speed of a wound rotor induction motor cannot be varied appreciably by the insertion of secondary resistance. For this reason it is useless to consider speed reduction by secondary resistance for such rolling mill drives.

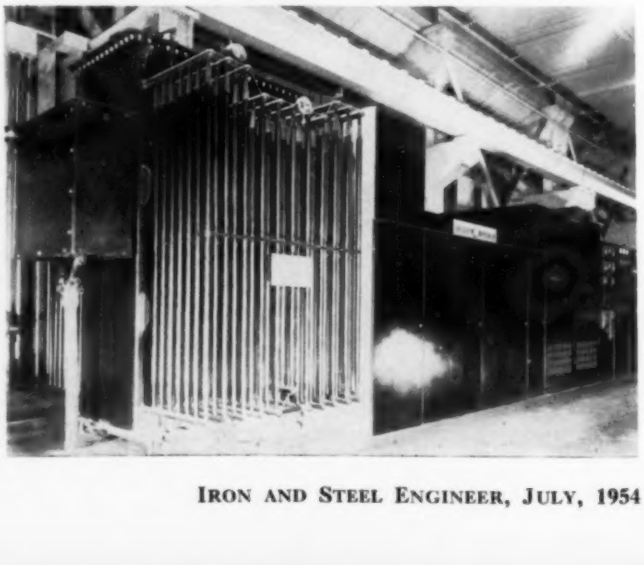
Controlled Excitation for Synchronous Drives—For synchronous machines, controlled excitation systems are becoming ever more popular. They are of particular value where the load on the motor is intermittent, is applied rapidly and sometimes suddenly, and is of high peak value. Such load conditions are met, for example, on the roughing stands of hot strip mills, and on the piercing and plug mill drives on seamless tube mills. Without an excitation regulator, the synchronous motor field current must be maintained at a sufficiently high value for the pullout torque to exceed the highest torque the motor may be called upon to develop. Otherwise, a danger exists that the motor may fall out of step. Where the peak load is very much in excess of the rms load, an over-sized motor would have to be used to obtain the necessary high pullout torque. With an excitation regulator, the field current of the synchronous motor is controlled in accordance with the load. At times of light load, the field current is held at a lower value than the maximum continuous current. Field losses and armature losses are reduced since the reactive kva is not kept unnecessarily high as with fixed excitation. When the load is applied to the motor, the field current is boosted, if necessary, above the continuous rated value, to obtain the required pullout torque.

Further advantages resulting from the use of automatic control of excitation are that the synchronous motor, being physically smaller in some cases than would otherwise be necessary, takes less current at starting. Furthermore, power factor or reactive kva may be regulated to either hold essentially constant power factor, or to furnish a constant value of reactive kva to minimize bus voltage regulation.

In a frequently used form, the power factor regulator consists of a two stage rotating amplifier arranged to buck-boost the field excitation of the synchronous motor exciter. Power factor adjustment is obtained through the use of a phase adjusting selsyn; reactive kva control through the use of a variable voltage transformer. In addition, the regulating system provides maximum and minimum excitation limit and stabilizing circuits.

For many years after the advent of large motors, most rolling mills were driven by wound rotor induction motors. However, with the development of the

Figure 4 — A completely self-contained, metal enclosed, pumpless rectifier unit substation is the modern a-c to d-c power conversion equipment for continuously running, infrequently started and stopped drives.



synchronous motor to its present high level of performance and dependability, most single motor constant speed mills are now driven by synchronous motors. The roughing stand drives on the modern continuous hot strip mill are an excellent example. During recent years there has been a trend toward larger coils of finished strip with resulting thicker slabs into the roughing stands. The increase in hot mill roughing stand power is more than offset by the overall increase in production resulting from increased output of the slabbing mill. Controlled excitation is used on these synchronous driving motors to achieve high pullout torque during the interval the slab is in the mill.

However, whether the drive under consideration utilizes a wound rotor induction motor with flywheel, or a synchronous motor, both electric systems will rely to a very considerable extent upon regulating control equipment to obtain optimum system performance for the metal rolling process involved.

Adjustable Speed Drives—Adjustable speed drives for rolling mills break down into two classes as to mode of operation. Basically, the mode of operation, or classification determines the type of a-c to d-c conversion equipment used to supply power to the main roll drive motors. For reversing and frequently accelerated drives, motor-generator sets are preferred as the source of d-c power. For continuously running mills, infrequently started and stopped, the mercury arc rectifier is rapidly displacing the motor-generator set as a source of d-c power supply.

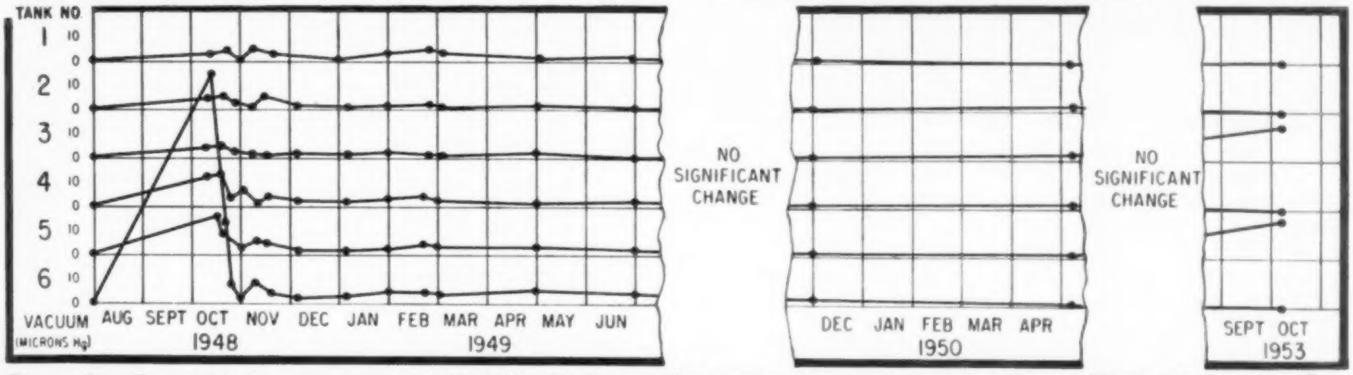


Figure 5 — Graph shows vacuum retention in all six rectifier tanks of a pumpless rectifier at Wickwire Spencer Co., Buffalo, since it was energized in August 1948. This is conclusive proof that the tank is an outstanding performer.

For reversing mills and mills that must be frequently accelerated and decelerated, motor-generator sets are used because of their inherent ability to regenerate power without complicated switching and because of the ease with which continuous and fully adjustable voltage control can be obtained. Motor-generator sets also offer the further advantages of d-c voltage being independent of a-c system voltage and of power factor correction. Peak loads encountered on reversing blooming and slabbing mill drives need not be taken by the power system if the motor-generator set is driven by a wound rotor induction motor with flywheel.

On the other hand, the advantages of rectifiers for continuously running mills, infrequently started and stopped, are well recognized as lower first, installation and maintenance cost, higher momentary load capability, higher efficiency, and no contribution to fault in the a-c system. The introduction of the compact, metal enclosed pumpless rectifier unit substation further enhances the future of rectifiers as a power supply for main roll drives because they provide additional reduction in installation cost, cut installation time, increase safety to personnel and equipment, and make low rectifier maintenance even lower.

Installation costs and time are reduced because the integrated unit arrives in the plant ready to connect and operate. It requires less space; the wiring done after delivery is almost negligible. One of the major considerations leading to the selection of pumpless rectifiers on recent main roll drives has been that these equipments eliminate a major maintenance problem on rectifiers—the vacuum pumping system. No longer is it necessary for the user to employ a vacuum maintenance expert or to even worry about the vacuum. The pumpless construction has only a minimum of moving parts to maintain or replace, no vacuum pump losses, no water needed to cool mercury pumps and easy spare tank installation making for continuous low cost service.

Records show that pumpless rectifiers have fewer arc backs than pumped rectifiers because the pumpless construction eliminates the possibility of mercury migration between tanks through common vacuum headers that exist on pumped rectifiers. The return of this mercury through exhaust lines and splashing on anodes is a cause of arc back in pumped rectifiers. In addition, pumped rectifiers have leaks or the pumps would not be needed to maintain the vacuum. The tighter the vacuum tanks, the better the rectifier and its performance. Figure 5 is a graphic representation of vacuum retention by all six rectifier tanks of a pumpless rectifier placed in service in August 1948.

Among other things, the record proves the following:

1. Pumpless rectifiers can certainly last six years without reconditioning.
2. European experience indicates that they could conceivably last 20 years.
3. It is possible for poor vacuum condition to improve with service, since nothing was done to tank 6 at the peak of its 1948 so called "bad spell."

Adjustable voltage operation over a limited voltage range may be obtained economically with a rectifier power supply. If drives are to operate at reduced voltage levels continuously, transformers with suitably tapped extended primary windings or regulating auto-transformers to cover the voltage range may be

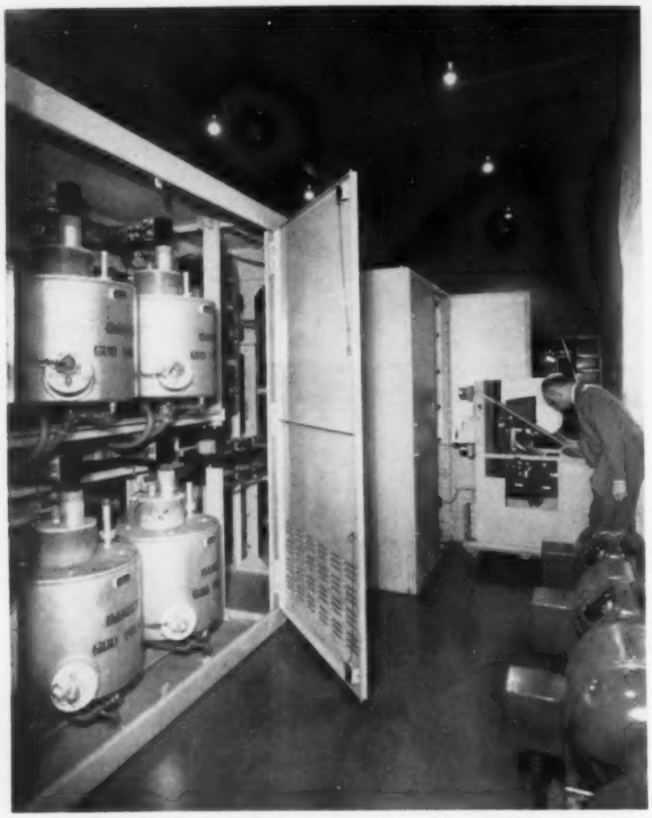


Figure 6 — Main drive metal enclosed pumpless rectifier substation shows pumpless tank excitation and auxiliary control, and cathode breaker units.

provided. Open circuit motor operated tap changing systems, which are relatively inexpensive, require that the mill be shut down long enough to select the proper tap and then re-start. If it is desired to change taps without stopping the mill or under load, then more expensive load ratio control equipment must be included in the system. Rectifier drives may be started from standstill and accelerated smoothly by phase control of the rectifier on an infrequent basis.

Magnetic amplifier regulating systems are used on mercury arc rectifiers for both main drive and constant potential supply service. The magnetic amplifier is ideally suited to the characteristics of the ignitron rectifier. Both are non-reversing and both have transient characteristics that combine together to give the ignitron mercury arc rectifier unmatched voltage regulating system performance. For parallel operation with existing motor-generator sets, it is common practice to use a combination magnetic amplifier—rotating regulator system. Essentially, the magnetic amplifier equipment takes care of the rectifier and the rotating regulator takes care of the d-c generator. An auxiliary magnetic amplifier or rotating regulator equipment is utilized to insure parallel operation.

While adjustable speed drives fundamentally break down into the two classes perviously described, it is convenient to sub-divide the first group, that is, the reversing and frequently accelerated drives. On blooming mills, slabbing mills, plate mills and reversing roughing mills, the important characteristic is the reversal. On cold strip mills the important characteristic is coordination between stands and reel, or between a single stand and reels during acceleration and deceleration. Reversing hot strip mills fall to some extent under both sub-classifications, but because of the coordination problem, and slower acceleration, have generally been classified with the cold strip mill.

Consideration of the problems of the electric systems for the three classifications of drives will be in the conventional order of process of the metal through the steel plant.

FREQUENTLY REVERSED DRIVES

The most important of those drives characterized by frequent reversals are the blooming and slabbing mills. All the rolled products of the steel plant pass through these mills. For this reason, these "work horses of the steel industry" have been receiving considerable engineering attention. As finishing facilities have been increased or speeded up, there has been an ever increasing demand to raise the output of the reversing mill. The output of this mill, as of any mill, is very much related to its utilization factor. If there is no metal in the mill, there is no output. This is an important consideration because on most reversing mills, the slab will be in the mill generally less than 50 per cent of the time. The remaining time is spent in manipulating, starting and stopping. For this reason, careful attention must be paid to each auxiliary and its drive if best possible productivity is to be obtained.

The recent interest in fast reversal of blooming and slabbing mill main drives has placed additional emphasis upon the auxiliary drives. Extremely fast reversals require somewhat special and more expensive equipment for both the main drives and the auxiliary drives. If the time of reversal of the main drive is short, then the manipulating, etc. should be done in less time, possibly meaning more horsepower and more excitation system power. The auxiliaries must keep up with the mill, and the interval between passes must approach the mill reversal time if increased production is to be achieved because of the fast reversals.

Most of the reversing mills installed during recent years have been powered by twin drive motors. Twin drive motors generally have about two thirds the WK^2 of single armature motors. Since the mill WK^2 is usually a small part of the total, twin drives are capable of faster reversal than single armature drives. Of course, the same comments would apply to a mill driven through a pinion stand by a double armature motor. However, the two armatures can be used to better advantage as a twin drive rather than a single drive. Basic twin drive advantages are flexibility in selection of roll diameters and elimination of pinions. Possible faster reversal has usually been considered as a secondary benefit. The heavy duty motors used on reversing drives are characterized by high peak load commutating capability, reduced armature diameter, long stacked length and increased temperature rise—50 degrees C instead of 40 degrees C.

Speed range by motor field control also affects reversing ability. A motor with a wide speed range is a physically larger motor with greater WK^2. It not only takes more amperes to reverse it in a given time, but it is more difficult to control when operating at top

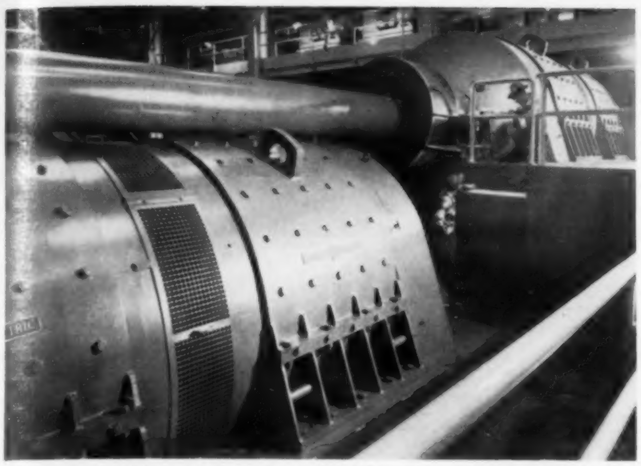


Figure 7 — New Jones & Laughlin blooming mill drive, rated 12,000 hp, 70/140 rpm, replaced steam engine drive in September 1953 and has since many times broken previous long standing steam engine 24-hour and 8-hour tonnage records.

speed with extreme field weakening. If reversal time is not lengthened, the drive may suffer commutation-wise.

Mill rolling slabs generally achieve maximum production by limiting speed range by motor field control to 2:1 or less. Even when rolling blooms there is an increasing tendency to restrict motor excitation speed range to 2½:1 or less.

Flywheel motor-generator sets with wound rotor induction driving motors are most commonly used to supply d-c power. However, a 6000-hp, 40/100-rm twin drive mill has been operating in the Detroit area since 1950 with d-c power being supplied by a synchronous driven motor-generator set. The driving motor is provided with rotating regulator controlled excitation to minimize bus voltage fluctuations. Experience on this drive has been very satisfactory. The synchronous driven set while passing the load peaks to the power system, does have the advantages of simplicity and lower first and installation cost.

The control system used on modern reversing blooming and slabbing mills is of the combination magnetic amplifier rotating regulator type. The inherent reversing capability of the rotating regulator is ideally suited to supply the strong reverse forcing required to achieve rapid reversal of the mill drive. The magnetic amplifier even though it possesses the irreversible characteristics of its rectifiers, makes it possible when used as a pre-amplifier, to obtain certain refinements in operation. Teamed together these two regulating tools work to achieve better utilization of the mill providing greater return on the overall investment.

A new twin drive recently placed in service rolling blooms in the Pittsburgh area has the fastest rate of reversal in the world—150 rpm per second. Rated 12,000-hp, 70/140 rpm, this double armature twin drive replaced a steam engine long considered a grand old champion in the steel industry.

To study the problems involved in changing from the steam to electric drive, a scale model was built of the existing steam engine foundation and the foundation of the new 12,000-hp motor. This model was disassembled and assembled piece by piece to study and demonstrate the individual steps which had to be taken in order to modify the existing foundation and to install the electric motors. To insure minimum interruption in production, all of the electric equipment including the switchgear, motor-generator sets, ventilating equipment, exciter sets, and control equipment were completely installed and tested on the site before the steam engine was shut down. In addition, prior to this all electric systems had been set up on an electronic differential analyzer and all operations simulated. Main drive voltage systems, motor field systems and screwdown systems were "operated" by means of master switches and performance of magnetic amplifiers, rotating amplifiers, exciters, and main drive motors and generators was recorded on the computer's oscillograph. Feedback control systems were adjusted to give the "feel that the engineers and operators desired." Relay, resistor and capacitor circuits were then determined from the computer. Then the control equipment was adjusted for the desired operation during manufacture.

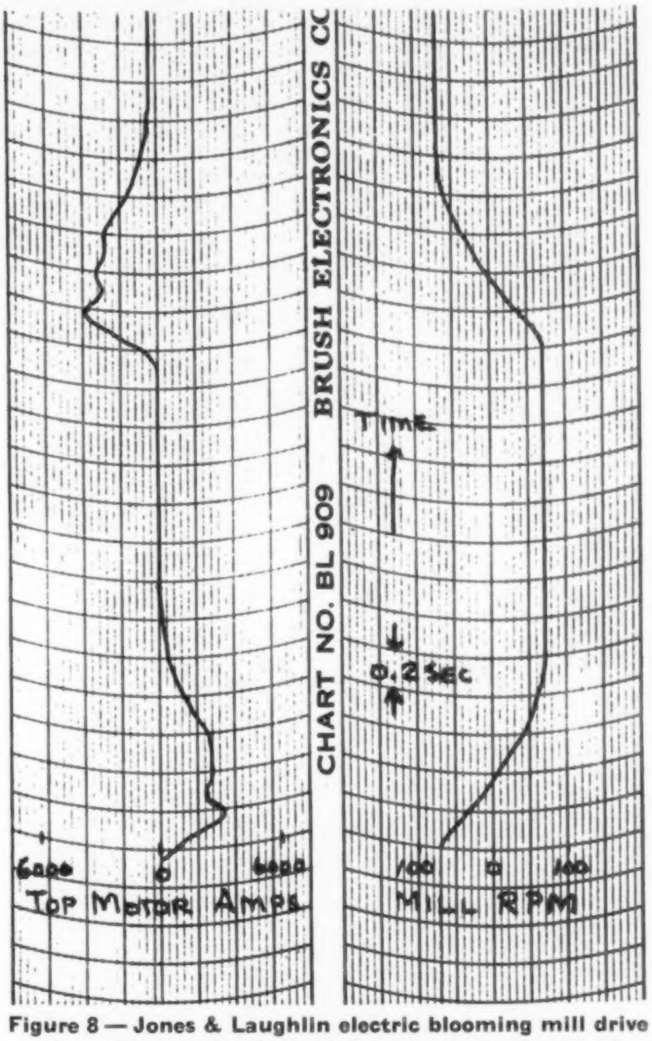


Figure 8 — Jones & Laughlin electric blooming mill drive has what may be the world's fastest rate of reversal — 150 rpm per second — reversing from base speed to base speed in less than one second.

Seven days, 14½ hours after the last ingot was rolled on the old mill, the first ingot was rolled on the new mill. Immediately, the roller blew for a second ingot and production was again under way. Forty-five days later and many times since, the new electric drive has

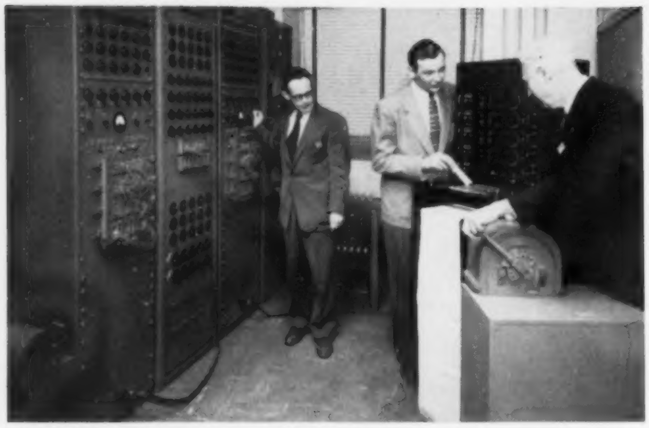


Figure 9 — Electric regulating systems for Jones & Laughlin blooming mill were "operated" on the electronic differential analyzer to determine system constants required for one second reversal.

broken previous long standing 24-hour and 8-hour steam engine tonnage records.

CONTINUOUSLY RUNNING DRIVES

Drives of this class run continuously at essentially constant speed and are infrequently started and stopped. Metal is threaded through the tandem stands "on the fly" and may be in all stands at the same time. Loads on individual stand motors may be adjusted by field control to obtain tension or looping in the metal between stands, but for a given schedule, the average speed of the motors is constant, as is the voltage applied to them.

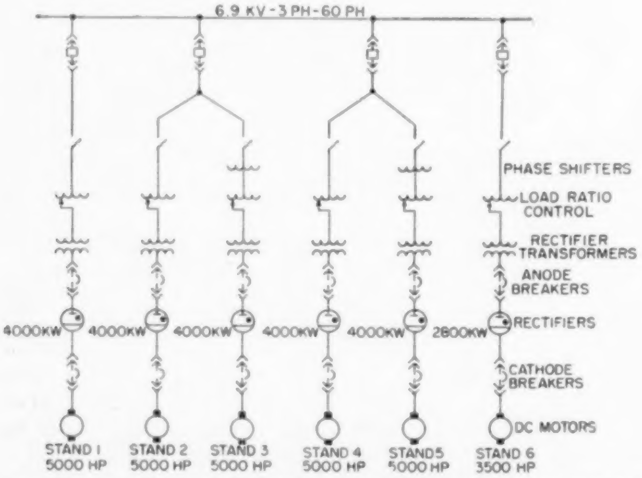

6.9 KV-3 PH-60 PH
PHASE SHIFTERS
LOAD RATIO CONTROL
RECTIFIER TRANSFORMERS
ANODE BREAKERS
4000KW
4000KW
4000KW
4000KW
4000KW
2800KW
RECTIFIERS
CATHODE BREAKERS
DC MOTORS
STAND 1 5000 HP
STAND 2 5000 HP
STAND 3 5000 HP
STAND 4 5000 HP
STAND5 5000 HP
STAND 6 3500 HP

Figure 10 — Hot strip finishing mill in the Detroit district will utilize six individual metal-clad pumpless rectifiers as a-c to d-c conversion equipment.

To meet the requirements of rolling schedules outside the speed range available by field control, the bus may be split into two or more sections and the mill operated continuously with reduced voltage on some bus sections. Starting at no load is infrequently required and is usually accomplished by raising the voltage on all bus sections, at a slow rate in approximately 30 seconds.

Hot strip and skelp mills, merchant and rod mills, continuous, "Assel" and piercing type tube mills fall into this classification for which rectifier power supply is ideally suited.

Hot Strip Finishing Mills—The trend on hot strip finishing mills has been towards more connected horsepower, and with considerable effort being expended to obtain better control of the product. As the connected capacity has increased, the pontential d-c short circuit currents and resulting forces have made it difficult to design satisfactory d-c bus systems. As a result, the trend has been to split the bus into sections with the advantages of reduced short circuit stresses and damage, increased flexibility in speed cone and rolling schedules, but with the disadvantage of loss in diversity of rolling loads. Finishing stands are powered individually on a 6-stand mill in operation in the Pittsburgh district. Each stand motor receives power from its own individual generator. Regulating systems are very much like those used on tandem cold strip mills except the small rotating regulator is used to obtain stand vernier speed control. This arrangement gives not only unlimited flexibility in the selection of individual stand speeds relative to each other, but improved transient performance on vernier speed control as well. Two more hot strip finishing mills are also scheduled to have individual stand power supply type drives, and will be mentioned later.

Four hot strip finishing mills are now in operation in this country having main drive motors powered entirely by mercury arc rectifiers. Three of these installations utilize essentially duplicate 5,000-kw equipments. One has been in operation on the West Coast since 1950 and the third was placed in service in the Pittsburgh district early last year. Last year two pumpless rectifier equipments were added to the bus of an existing hot strip finishing mill. Ten more pumpless equipments are being manufactured for the two hot strip finishing mills scheduled to have individual stand power supplies.

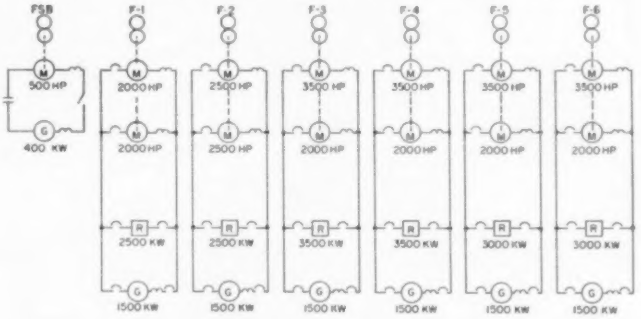

FSB
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Figure 11 — Pittsburgh district mill will be revamped to individual power supply for each finishing stand drive. Four new motors and four new metalclad pumpless rectifiers will give it greatest total horsepower and conversion kw in industry.

Figure 10 is a one line diagram of one of the individual power supply mills scheduled for installation in 1954. The finishing stands will be powered individually by six pumpless rectifier unit substations. This mill will be the first to utilize individual rectifier power supply and to provide individual voltage adjustment between stands when operating under load. Load ratio control transformers are being provided to permit continuous operation down to 60 per cent of rated voltage.

Figure 11 is a schematic diagram of a mill which after modernization, will have a total horsepower rating of main drive motors exceeding that of any other mill. Existing horsepower totals 23,000. Four new 2,000-hp motors and four new pumpless rectifier unit substations will bring the drive total to 31,000-hp and the conversion capacity to 27,000-kw. The power supply will be changed from a common bus to a separate supply for each stand as shown. Each system will operate at 600 volts. There will be one generator and one rectifier per stand. Provision is included to operate stands at different voltage levels by means of open circuit tap changers on extended primary windings of the rectifier transformers. Six taps will be provided for voltage reduction to 75 per cent of rated voltage.

Both of the hot strip finishing mill drives described are being provided with magnetic amplifier type motor field current regulators to obtain improved speed of response on vernier control of finishing stand motor speeds.

It is interesting to note that these two most recent hot strip finishing mill systems include so many of the features considered standard on tandem cold reduction mills. The flexibility and precise responsive control of the tandem cold reduction mill system will undoubtedly have the same advantages in the rolling of hot strip. The individual power supply per finishing stand motor will widen out the speed cone and reduce short circuit current. The forcing action of the motor field current regulating system will assist speed operators to avoid cobbles and at the same time, give them that precise responsive control of motor speed so necessary to operate a hot strip mill without tension between stands. Any significant reduction in neck-down of strip caused by tension will quickly pay for these regulating systems.

Rod Mills and Tube Mills—Continuous rod mills and seamless tube reducing mills are similar in that the transient behavior of the drives of both is important. They differ only in degree—such behavior being more critical on tube mills. Both types of drives have in general utilized rolling mill motors with low impact speed drop characteristics. Regulating equipment has varied from none to the best available.

As the front end of the metal hits each stand, there is an impact speed drop due to the sudden load application which is applied to each stand in succession as the front of the metal travels through the mill. This tends to upset the proper speed relationship between stands and may cause excessive looping or stretching of the metal between stands. On single strand mills with individually driven stands, a change in motor speed with load presents no great problem. An entering speed slightly above the load speed tends merely to take up the slack formed when the front end of a bar travels between stands. A speed decrease when the metal leaves the rolls is of little importance. Drives of this type are sometimes equipped with means to improve speed regulation but these serve here to assist the operators in handling the mill, and have little or no effect on the product.

Multi-strand mills or single strand mills with group driven stands introduce different operating requirements. A gap between bars in one strand of a multi-strand mill has the effect of successively reducing and increasing the loads of the various motors as the gap passes through the mill. Consequently the motor speeds tend to rise and fall slightly as load changes. The bar in another strand which may extend throughout the full length of the mill will be affected by these motor speed changes, as a rise in motor speed will increase the tension in the bar on the entering side of the stand driven by the motor and will tend to produce a loop in the bar on the leaving side of the stand. If these speed changes are too great or of a too prolonged duration, successive under-fills and over-fills may be produced in the bar.

This phenomenon does not lend itself to calculations determining the effect of speed changes on the quality of the product, or to a specification of the drive characteristics necessary to insure certain tolerances. Some of the factors affecting drive behavior, such as the magnitude of load variation and the electrical and mechanical inertias of the drive system, can be determined, although such calculations are practically endless when the wide ranges of speed and load of modern rod mills are considered. Other equally important factors such as the amount of metal deformation due to stretching and looping, how this deformation is affected by metal speed, the amount of load transmitted between motors by tension in the mill, and the effect of subsequent stands in reducing eccentricity are, at least quantatively, unknown. In addition, there is no general agreement as to what constitutes a "good rod" and some users will accept and sometimes prefer, rod for subsequent drawing that other users will reject.

It is apparent that the perfect drive for a continuous rod mill or a tube mill would be motors, the speed of which could be readily adjusted and, when adjusted, would be entirely unaffected by load changes. While no such motors exist, experience indicates that such perfection is not necessary for successful rod rolling and that motors with somewhat improved characteristics will furnish excellent rod mill drives. Since the loading and stretching of tubes cannot be tolerated, it has been the practice on these mills to use motors with considerably improved characteristics.

The speed matching control systems used on rod mills have varied from exciters connected across the motor auxiliary shunt fields and excited from motor load current to complete electronic-rotating regulator speed regulators controlling the motor field excitation. Armature circuit boosters with rotating regulator type IR drop or loop regulators, have also been used. Actually, rod mills vary greatly in layout, and consideration must be given to the layout in determining the requirements of the electric system. Mills operated with loops between stands generally require the least in speed compensation or regulating equipment. On closely coupled stands, looping cannot be tolerated and in such cases, the low impact speed drop (high inertia, low resistance, low inductance) motors and more accurate speed compensating or regulating equipment is required.

The modern high speed rod mill and the seamless tube forming mill are excellent examples of drive systems wherein the user is interested in a specified level of transient performance which can be achieved by many possible combinations of electric apparatus to form the electric drive system. The electrical application engineer has a choice of electronic, magnetic amplifier, rotating amplifier, or any combination of these regulating control equipments to use to regulate speed, voltage or current to achieve the desired results. External characteristics of rectifiers and motors can be specified over a broad range from standard rolling mill to extremely special characteristics. Today's electrical system engineer must utilize good judgement in drawing upon previous experience, and the results of his computer studies to specify the type of equipment and component equipment characteristics to obtain optimum performance at the lowest cost to meet the process requirements.

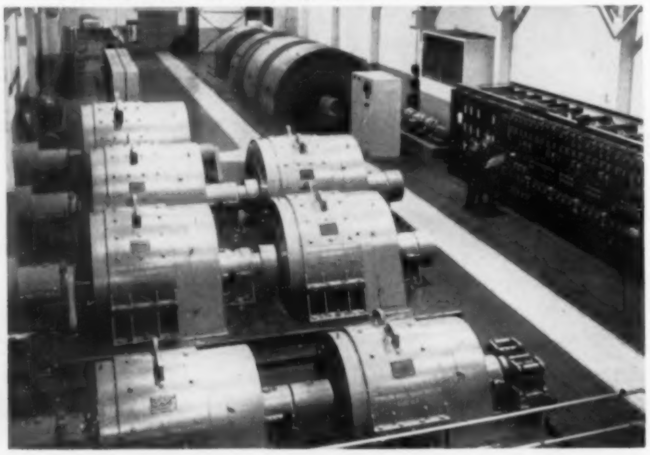
Merchant-Bar Mills and Skelp Mills—Electric systems as used on recent continuous merchant-bar mills and on skelp mills have been similar to those used on other forms of tandem hot rolling mills. Either provision has been made for sectionalizing the d-c bus, or it has been permanently sectionalized. Rectifiers have been the preferred type of conversion equipment. The d-c bus sections are always voltage regulated. Provision is often made to operate at reduced voltage by means of open circuit tap changes on the rectifier or on separate auto-transformers. Motors are normal rolling mill design with horsepower and speed ranges selected to best fit the required rolling schedules.

A skelp mill now in service on the East Coast, utilizes two 3000-kw pumpless rectifier unit substations to supply d-c power to the drive motors. Electric equipment is now being manufactured for an 11-stand skelp mill which will be powered by two 2500-kw pumpless rectifier unit substations. On both equipments provision is included to split the bus, and the drives may be operated continuously down to 75 per cent of rated voltage.

FREQUENTLY ACCELERATED DRIVES

Tandem and reversing cold reduction mills, temper mills, and reversing hot strip mills are characterized by frequent rapid accelerations and decelerations. These drives also require accurate coordination between stands and reel or between a single stand and reels during these periods.

Figure 12 — This 3-stand tandem cold sheet mill, in operation in Ohio, is one of most recent to be placed in service. Control system includes electronic memory type trouble locating equipment.



The advance in the art of cold rolling tinplate has been one of the most outstanding developments in industrial production. The change in 20 years from rolling this product at several hundred fpm with an output of a few tons per hour to rolling at 5000 fpm with an output of almost 1½ tons per minute with practically the same number of men, to put it mildly, required the solution of a number of rather difficult problems. These mills with their many motors and many regulating control systems are operated entirely through push-buttons and rheostats. They are outstanding examples of the automation that can be achieved with today's know-how, and are truly the monarchs of all coordinated drives in industry.

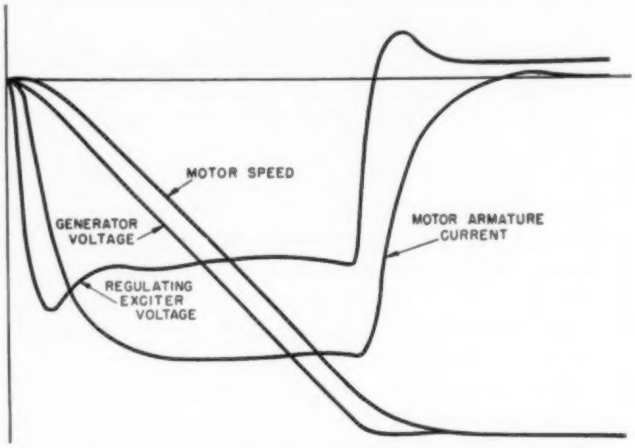


Figure 13 — Electric regulating control systems on tandem cold reduction mills must be designed for large amount of reverse forcing at low voltage levels to insure accuracy during deceleration to thread speed.

In no other type of rolling mill does the performance of the electric equipment affect the quality of the product to a greater extent than in the cold strip mill. The accuracy of the gage, the ease of maneuvering, the mill tonnage, and the per cent yield, all depend directly upon how well the electric drive system is coordinated. Not only must the systems be designed to operate over an extremely wide range of steady state operating conditions, but they must be designed to have a high rate of response so the changes in operating conditions may be made quickly with all stands acting together.

Ratings and design characteristics of the motors and the mill rotating parts are important. Motor speed regulations must be matched and follow a specified pattern from maximum on the first to minimum on the last stand. Tandem cold mill motors are also built with base and top speed regulation equal to the motor IR drop. These characteristics are obtained through the use of offset pole face windings and auxiliary shunt fields connected across the commutating and compensating windings. The matched external characteristics of the d-c generators and main drive motors are essential to the successful operation of the overall system.

Moments of inertia of motor plus mill must have the proper relationship between each other and to the motor ratings. The variety of products to be rolled requires that motors operate over at least a 2:1 field range resulting in considerable variation in accelerating current. Also, practical limitations in motor and mill design limit the extent to which it is possible to balance moments of inertia. Thus, it is impossible to specify or to obtain rotating equipment that will inherently remain in speed correspondence during acceleration and deceleration.

To maintain proper gage during periods of threading or low speed operation, and during acceleration and deceleration, the electric feedback control systems in conjunction with the inherent characteristics of the d-c motors and generators, should compensate both for unbalance of moments of inertia between stands and for the tendency for gage to vary during steady state rolling conditions. To obtain such a correction it is necessary to have a mill wherein the mill is "stretched out" as the operating speed is lowered, rather than a system acting to maintain perfect speed correspondence.

All large domestic tandem mills placed in service since 1947 have utilized individual generator voltage regulated load compensated schemes similar to that first used on Jones & Laughlin's 6000 fpm 5-stand mill. The load or IR compensation is used to obtain automatic gage control. The adjustment is simple and is readily available to the operator.

The ease of operation and the continuity of production almost cause the visitor to believe that the mill is operating in accordance with the operator's thoughts. It almost does, but not accidentally. It does because the steel industry application engineer thoroughly understood the problems associated with the tandem cold reduction of steel strip and knew how to specify machine and control system characteristics to satisfy the requirements of the process. It operates as smoothly as it does and at the high level of production because the system has been thoroughly analyzed and tested.

The electronic differential analyzer has been an extremely valuable tool in studying improvements to this much used control system. With the aid of this modern engineering tool, new circuitry was developed and is in operation on a 7000-fpm mill on the East Coast. Both the former standard circuit and the improved version were demonstrated to interested engineers and operating and maintenance supervisors prior to placing the mill in service. The modernized circuitry makes possible improved transient speed of response during threading of the mill stands, reducing to a new low the possibility of camber during threading. A year's operating experience has shown the new improved system to have the same wide stability margin and the other desirable operating characteristics which together with simplicity of circuitry, have made this drive system so popular in recent years.

During the last few years there has been as great a controversy regarding use of the type of regulating equipment—rotating amplifier, or magnetic amplifier—as there used to be regarding the quantity to be regulated—voltage or speed. There is no doubt but that the question will be resolved. Both have inherently different characteristics. The rotating regulator is familiar to all. One widely used form is a two-stage power amplifier. This form requires very little control power and has high speed of response. The characteristics have been obtained by a simple but ingenious system of field and armature connections on a machine very similar to a conventional d-c generator. Rotating regulators are inherently reversible as are conventional d-c generators.

The magnetic amplifier, a relative newcomer, is finding many applications in the steel industry. This type of equipment differs from the rotating amplifier in that the control element is a static device, combining a saturable core reactor and rectifiers in a self-saturating circuit. The magnetic amplifier has the irreversible characteristics of the rectifiers used in it. For rapid decelerating applications such as being considered, either two generator fields and two magnetic amplifiers must be used or efficiency must be sacrificed in the two magnetic amplifiers to convert them from inherent current amplification to reversing voltage amplification. In either case, two sets of reactors and rectifiers are required. In the first case, more copper is required on the pole pieces of the generator, usually meaning a larger generator. In the second case, larger magnetic amplifier units with a continuous internal power loss to be dissipated in the motor room are required.

Even when two fields are used on the generator, each magnetic amplifier unit may need to be larger than that required for slow or non-decelerating operation if a very short stopping time is required. The forward field and its magnetic amplifier rectifier circuit tend to behave as a shorted winding, and will act to slow down the voltage or the flux change called for by the increase in current in the reverse or decelerating field. Each application of self-saturating magnetic amplifiers for such duty must be completely studied: first, to determine the suitability of the application; and second, to determine the most suitable means of obtaining reverse forcing for that particular application.

During recent years the majority of single stand cold reduction mills have also been supplied with individual generator drives. Speeds are usually 2000 fpm or less except for aluminum foil mills where speeds of 4000 fpm are common. Rates of acceleration and deceleration are usually much slower than those used on tandem cold reduction mills.

Temper Pass Mills—The variation in electric systems used on temper mills or skin pass mills is greater than on cold reduction mills. Single stand skin pass mills without pullers generally utilize electric systems similar to those of single stand non-reversing cold reduction mills. There is, however, usually considerable variation between other temper mills. Single stand mills with pullers and two-stand mills with pullers each require study as to arrangement of armature circuits and selection of d-c generators. Single stand temper mills without pullers generally utilize individual generator systems. However, mills utilizing pullers and two-stand mills may consist either of a common bus generator system or a combination of common bus with individual generators for reels. The actual arrangement depends upon economic considerations affected by actual drive motor ratings.

In selecting drive motor ratings and laying out regulating control systems, special attention must be given to the problem of accelerating and decelerating the mill. It will generally be found that the horsepowers required to achieve a given strip temper will not be sufficient to accelerate or decelerate the drives in less than approximately 20 seconds. Many times it is necessary to increase the horsepower of the payoff drive in order to achieve even this rate of acceleration or deceleration.

Use of the common bus generator system permits greatest flexibility in rolling practice at lowest installed cost. The main d-c generator need only be large enough to take care of strip temper requirements. With a strict individual generator system, considerably greater generator capacity would be required, since the total generator capacity would be equal to the sum of stand drives plus forward and back tension kilowatts.

Regulating control systems on temper pass mills are very similar to those used on cold reduction mills. Basic control is by regulation of generator voltage. Pullers and reels are provided with current regulators. On two-stand temper mills, a tensiometer is used to regulate the tension between stands. The tensiometer signal is fed into the regulating system which modifies booster voltage to control stand one speed and thus tension between the stands.

Reversing Hot Strip Mills—Electric systems for reversing hot strip mills are a combination of those used on other drives. The rolling mill drive system is basically the same as that used on the reversing blooming and slabbing mill. Furnace coiler drives are a combination of systems used on reversing cold reduction mills and on hot strip mills. Various degrees of automatic and semi-automatic control are usually provided to obtain the proper coordination between hot mill and furnace coilers. The problems associated with the auxiliary drives are of as complex a nature as those of the main drive.

SUMMARY

Electric system requirements vary with each type of mill drive. External characteristics of motors and generators of the same ratings are different for the various rolling processes. With today's analytical know-how, today's regulating equipment, and most important, today's experience, it is possible to specify machine characteristics, to select the proper type of feedback control systems, the proper type of regulating equipment, and to predict the system performance. The equipment goes into service quickly and performs as predicted. Electric equipment can be designed and built to achieve the increased automation and improved performance being specified by industry to achieve improved product quality, increased output and reduced unit product cost.

DISCUSSION

PRESENTED BY

W. R. HARRIS, Manager, Industries Engineering, Westinghouse Electric Corp., East Pittsburgh, Pa.

W. E. MILLER, Manager, Steel Mill Engineering, General Electric Co., Schenectady, N. Y.

W. R. Harris: This paper shows the importance of the electric drive to the mill operator and to the modern high tonnage mill. The trend to high speed and to more continuous processes has led to more and more complex electrical drive control equipment. In general, if the speed of a mill or processing line is doubled, the drive horsepower is double, but the stored energy in the mill parts increases by a ratio of four. The controllability of a mill during acceleration and stopping may be taken as the ratio of stored energy to horsepower. Thus at twice the speed the drive is twice as hard to control. Proper control under such conditions is beyond the ability of the human machine, and so regulating systems find more and more use as cited by Mr. Miller.

The mill and the electrical manufacturer are to be congratulated on changing over the J & L blooming mill from steam to electric drive in such a short time. This took some real planning and excellent coordination of effort.

I would like to take issue with Mr. Miller on his use of rpm per second as a criteria for judging rate of reversal on blooming mill drives. The time in seconds is the proper term to use. It is no more difficult to reverse a 70-rpm base speed drive than it is to reverse a 40-rpm or even a 30-rpm base speed motor. In each case the time constant of the generator field and the amount of forcing to the generator field results in the reversal and the base speed of the motor has nothing to do with the problem. Therefore, rpm per second is apt to be misleading.

In considering the advantages of synchronous-driven sets or flywheel sets for peak load mills, the power peak on the system must be given serious consideration. For instance, a 7000-hp blooming mill drive normally carries a 5000-hp wound-rotor motor on the flywheel set, and the slip regulator is usually not set in excess of 5000 kw input. The d-c mill motors of such drives are rated for peak torques of 2.75 times rated. This is about 19,000-hp peak from the 7000-hp motor. This results in about a 23,000-hp or 17,000-kw steady-state demand from the a-c line. However, a synchronous motor or sudden application of load will swing to about twice the steady-state load which means that about 34,000 kva will momentarily be taken from the line. This is a far cry from the 5000 kva with the flywheel set. In most large plants this would be of no serious consequence, but in the smaller plants it can be serious.

Under tandem cold reduction mills, Mr. Miller has cited that an improved control circuit was necessary for a 7000-fpm mill. Since Mr. Miller does not detail this circuit in the paper, I would like to ask him to do so now and also to tell us why the improved circuit was necessary.

Under temper pass mills, Mr. Miller states that the main d-c generator with the common bus system need only be large enough to take care of strip temper requirements. I would like to point out that on most recent high-speed temper mills, the selection of generator capacity has been based on the stored energy in the mill parts and the accelerating rate rather than the steady-state load requirements. As cited earlier, the stored energy increases when the speed is doubled, which has made a real accelerating problem on some of the two-stand high-speed temper pass mills. A serious error can result on such mills if the generator is selected on steady-state requirements alone.

W. E. Miller: Mr. Harris has raised a number of questions which will require some detail to answer properly.

I believe an extension of the fundamentals laid down by Mr. Harris can be developed to justify the use of rate of reversal as a criterion for judging blooming mill drives. I agree that one criterion is reversal time, but rate of reserval is a factor in controllability of the drive as affected by the increase in the ratio of stored energy to horsepower cited by Mr. Harris.

Comparison of reversal times alone compares only the generator excitation systems, and does not take into account the regulating system refinements and margin required for the same degree of performance of motor drives of varying controllability.

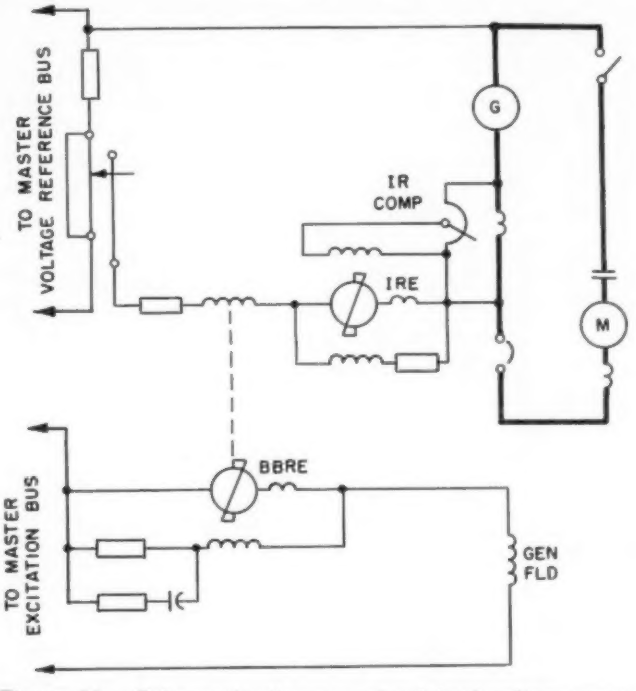


Figure 14 — Schematic diagram of original voltage regulating system for individual generator tandem cold reduction mills first installed in 1947 on 6000-fpm mill.

Motor drive controllability problems increase as the product of hp x rpm because of an increase in the ratio of stored energy to horsepower of the d-c drive motors. This ratio is actually over 40 per cent greater for a 12,000-hp, double-armature, twin-drive at 70/140 rpm than for a 12,000-hp double-armature, twin-drive designed for 40/80 rpm.

Controllability is a problem not at base speed, but at top speed; the problem increasing as the square of the speed range by motor field weakening. It is four times as difficult to control a 2/1 motor at top speed as it is at base speed. Controllability is reflected as ability or inability to limit initial pumpback current peaks during reversal.

Thus, for the same reversal time, the same horsepower, and the same speed range by motor field control, the higher base speed drive is more difficult to control and requires a more highly refined regulating system with greater design margin and rate of reversal is a criterion for comparison.

I agree with Mr. Harris that wound-rotor, induction motor, flywheel-driven motor-generator sets are usually to be preferred for blooming and slabbing mills. The subject was brought up only to point out that synchronous driven sets have lower first and installation costs and that in some cases they can be used. Also, they will not pass any larger transient peaks to the power system than synchronous motors of the same horsepower that may already be driving hot strip roughing stands in the same plant.

Blooming and slabbing mill drives are rated 225 per cent frequently repeated load and 275 per cent occasionally repeated load. Even with these peaks the steady state or rms load can only be 100 per cent or the drive would overheat. Between load peaks are periods of zero or light load in order that the root mean square load be 100 per cent. Therefore, I do not believe that the steady state demand, or I think Mr. Harris means average demand by the synchronous-driven motor-generator set, can be the three times the d-c rms rating as stated by Mr. Harris. Average demand must be less than the rms rating, because the peaks have a square effect on the rms load and not upon the average load.

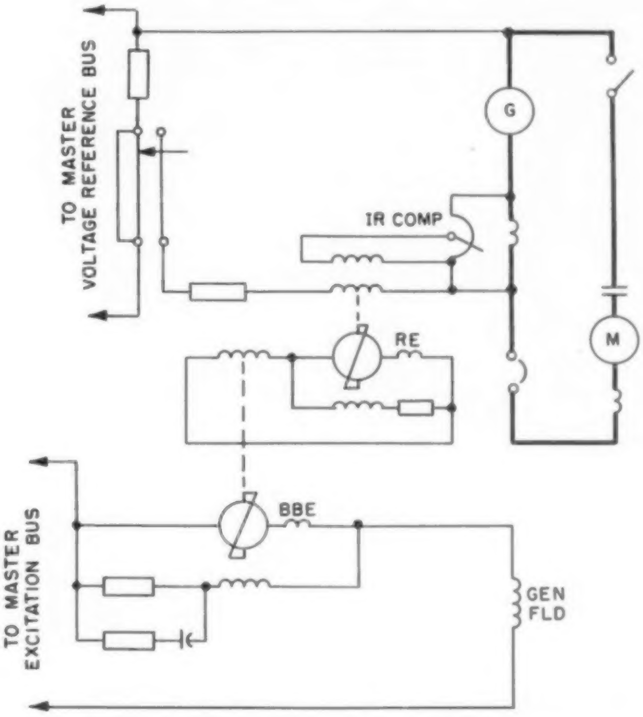


Figure 15 — Schematic diagram of modified voltage regulating system for individual generator tandem cold reduction mills installed in 1952 on 7000-fpm mill.

Use of a synchronous driving motor does impose transient peaks upon the pass peaks. The transient peaks usually decrease to substantially the normal pass peak in about three seconds. During this interval the load imposed upon the power system oscillates at a frequency of about three cycles per second. For a 7000-hp, d-c drive, I believe load peaks imposed on the power system would more normally be as follows: normal pass peak 14,000 kw, maximum occasional momentary transient peak 34,000 kva, maximum frequently repeated momentary transient peak 28,000 kva, average demand 7000 kva or less. Because of the preceding factors, use of a synchronous drive on the motor-generator set will be more apt to cause voltage fluctuation problems than it will be to significantly affect plant demand in the plant where such drives are apt to be used.

Improvements are continuing to be made in control systems for tandem cold reduction mills as well as reversing blooming mills and many other drives. While we are very proud of the record-breaking performance achieved by the Jones & Laughlin 6000-fpm tandem cold reduction mill and the universal acceptance of that basic control system, we still believe in further progress.

The only necessity for the improved circuit that I am aware of is the necessity, or really the urge to progress, especially when it is possible to obtain such progress without increase in cost or complexity of the system.

The electronic differential analyzer makes it possible to study variations in control systems easily and comfortably. Differences in performance can be evaluated without lengthy factory or mill tests. As explained in the paper, performance of each system was determined on the computer and the decision was made to use a modification of the original regulating circuit. Simplified schematics of both are shown in Figures 14 and 15. It will be noted that the original system had one two-stage rotating regulator in the regulating loop. The modified system has two such rotating regulators in the regulating loop giving four stages of amplification.

Rather than use the full available increase in overall amplification, the various stages were partially degenerated, reducing time constants. Using the computer it was possible to determine the new stabilizing circuit constants necessary for stable performance without trial and error factory or steel plant testing.

The first steel ever to be produced on a tandem cold strip mill utilizing a completely static (magnetic amplifier) stand and tension reel regulator was rolled early in 1954 at the Indiana Harbor plant of the Youngstown Sheet & Tube Co.

The mill was supplied with conventional rotating-regulator regulating systems for all stands and the reel. However, in an effort to evaluate the benefits derived from the use of an all-magnetic amplifier control, 400-cycle, magnetic amplifier equipment was built as an alternate for the fourth stand or reel. Thus, with a flick of a switch, these two regulators can be changed from rotating to magnetic amplifier control, making possible a careful comparison of the rolling characteristics of the two systems on the same mill and drive equipment.

Other tandem mill systems are under development. The final goal is best performance and simplicity of circuitry for reliability and maximum production.

Several recent papers have been devoted to the power requirements of temper mills. The scope of this paper did not permit presenting a complete study of this problem, but only conclusions drawn from these papers and studies associated with several recent high speed

TABLE I

Temper Mill Rolling Schedule Calculations
38-in. Wide Steel Strip at 6000 FPM

	Feed reel		Entry puller	Stand 1	Stand 2	Delivery puller		Winding reel		Generator
	Empty	Full						Empty	Full	
Motor hp	400 kw		300	800	1200	1200		600		2000 kw
Motor rpm	300/1500		850/1500	400/600	1150/1500	800/1500		300/1500		....
Motor WK^2	3500	3500	380	2800	1120	1120		3100	3100	....
Mill WK^2	1200	197,200	3610	183,000	24,900	4510		1200	197,200	....
Total WK^2	4700	200,700	3990	185,800	26,020	5630		4300	200,300	....
Motor torque at actual rpm	1835	8230	1300	9100	4870	5100		2050	9230	....
Torque to accelerate in 20 sec	1100	10,450	795	13,000	5160	1120		1005	10,450	....
Per cent motor torque to accelerate 20 sec	60	127	61	143	106	22		49	113	....
						Top	Bottom			
Temper load Per cent motor rated	68G	68G	88G	51G	97M	92M	50M	71M	71M	....
Per cent net load accelerate	86	59M	27G	92M	203M	114M	70M	120M	184M	208
Per cent net load decelerate	128G	195G	149G	194G	9G	70M	28M	32M	42G	105

Notes:
G — Generating Load.
M — Motoring Load.

Assumed rate of acceleration and deceleration — 300 fpm/sec temper mills. It is generally agreed that the common bus system will permit use of less generator capacity than if a separate generator is used with each motor. With all drives fed from a common bus, full advantage is taken of pumpback power and the total load on the generator is limited to rolling load plus losses and minimum generating capacity is necessary. With individual generators, each generator must be capable of supplying the maximum load of the drive it supplies regardless of whether that drive is motoring or generating. This naturally results in a total generator capacity considerably greater than that required to supply the total net load.

It is generally held that the maximum continuous load which is imposed upon the generator supplying the common bus load, occurs when stand two, the delivery puller, and the winding reel, are fully loaded and there is practically no return power by pumpback from stand one, the entry puller, or the unwinding reel. It was suggested in the paper that the generator be selected upon this basis.

For example, a 5000-fpm two-stand mill that has been in operation for a number of years has a total of 3135-hp supplied by one 1750-kw generator. A similar 6000-fpm mill that has also been operating for a number of years has one 2000-kw generator supplying power to a total of 4635 hp in drives.

These high speed temper mills were not designed to accelerate or decelerate at rates comparable to tandem cold reduction mills. Previous AISE papers on the subject have suggested a rate of 250 fpm per second. The two mills referred to are capable of slightly greater than this rate.

It is always desirable to check the accelerating and decelerating ability of temper mills. The various drives should be compatible in accelerating and decelerating ability. An analysis will indicate that a primary consideration on high speed mills is machinery WK^2 and not motor WK^2. Attempts to increase the rate of acceleration and deceleration will require corresponding increase in peak hp of the drive motors. When accelerating, winding reel motors are usually the first to reach their permissible overload ratings. When decelerating, overload ratings of stand one and the unwinding reel will be the first to become involved. Peak hp may be increased either by using motors with greater overload ratings or by increasing the actual nameplate rating.

Table I tabulates one possible mill setup for temper rolling of 38-in. wide strip at 6000 fpm on the mill previously mentioned. Calculations have been based upon data published in AISE Proceedings for 1950 and 1952 except that an accelerating rate of 300 fpm per second was used instead of the 250 fpm per second suggested as normal in the previous papers referred to. It will be noted that should a faster rate of acceleration or deceleration be required, that it will be necessary to increase drive motor peak ratings on feed reels, stand one winding reels as well as the main d-c generator.

GRADUATE SCHOLARSHIP GIVEN TO CARNEGIE TECH MAN

W. L. DOLLENMAYER

▲THE second in the series of AISE fellowships for graduate study in mechanical engineering was given to William L. Dollenmayer of Charleston, W. Va., for the coming academic year of 1954-55. The fellowship is one of the educational and research activities of the Association of Iron and Steel Engineers and is aimed at training and interesting outstanding men in the iron and steel industry. Mr. Dollenmayer was graduated from Carnegie Institute of Technology with a B.S. in mechanical engineering in June, 1953, and received an M.S. degree in June, 1954. He plans to continue his studies at Carnegie Tech and will work for a Ph.D.

Mr. Dollenmayer has also been employed in the engineering department of Carbide and Carbon Chemicals Co. at Charleston during the summers, working on mechanical design and studies of pump details. While at Carnegie Tech he participated in a number of school activities and is an avid radio ham. Under provisions of the fellowship, Mr. Dollenmayer will receive a financial grant plus tuition and allowances for equipment necessary for his studies toward an advanced degree.

CLEANING OF OPEN HEARTH CHECKERS AND SEWERS DURING OPERATION

By R. M. JORDAN, Assistant Superintendent, No. 3 Open Hearth, Bethlehem Steel Co., Lackawanna, N. Y.

. . . . success of any checker cleaning program depends upon constant checking that everything is in order . . . . the use of water and air to blow checker openings, and installation of agitators to blow the sewers have solved the problem at Lackawanna . . . .

▲ IT is an established fact throughout the steel industry today that the higher the preheat of the combustion air, the more efficient the operation of the open hearth furnace. During the past several years much discussion has been given to the subject of increasing the temperature of the combustion air by better checker design and by keeping the amount of air infiltrated into the checker chambers at a minimum. The maximum preheat obtainable from any one checker design is dependent on the condition that all flues in the system be in use. If part of the flues become plugged with dirt during the furnace campaign, the efficiency of the checker is lowered, due to the decrease in the total heating area and the increase in the flue velocity. This results in a lower preheat of the combustion air, with a corresponding drop in the efficiency of the furnace. Therefore, if a furnace is to be kept operating at top efficiency throughout its campaign, the checker flues must be kept clean of dirt.

The Lackawanna Plant of Bethlehem Steel Co. has 34 open hearth furnaces, divided into three open hearth shops. No. 1 open hearth was built in 1906 and has fourteen furnaces, each tapping 145 tons per heat. These furnaces are equipped with single-pass checkers with 5½ × 5½-in. chimney-type flues. Oil and high-pressure coke oven gas are fired on two furnaces, pitch and high-pressure coke oven gas on another, and straight oil on the remaining eleven furnaces.

No. 2 open hearth was built in 1915 and has 10 furnaces. One furnace in this shop, completely rebuilt with front flush and bifurcated spouts, taps 300 tons per heat. Another furnace, modified to front flush and bifurcated spouts, taps 280 tons per heat. The other eight furnaces tap 150 tons per heat. The two large furnaces and six of the small furnaces are equipped with double-pass checkers with 7½ × 7½-in. chimney flues in the hot passes and 5½ × 5½-in. chimney flues in the cold passes. The remaining two furnaces are equipped with single pass checkers with 5½ × 5½-in. chimney flues. In this open hearth shop five furnaces are fired with a combination of high-pressure coke oven gas and pitch and five with high-pressure coke oven gas and oil.

No. 3 open hearth was put in operation in 1936 and has six furnaces tapping 220 tons per heat. Late in 1952 and early in 1953 four additional 250-ton furnaces were added to the shop. These furnaces all have double-pass checkers with 7½ × 7½-in. chimney flues in the hot pass and 5½ × 5½-in. chimney flues in the cold pass. A combination of high-pressure coke oven gas, pitch and Bunker "C" oil is used in the furnaces, in the proportion 60 per cent gas, 30 per cent pitch and 10 per cent oil. The maximum fuel input is 750 equivalent gallons of oil per hour on melting down.

The attention recently given to checkers and their maintenance may be ascribed to the increased amount of dirt resulting from the extended use of pitch as a fuel on a larger number of furnaces and from the additional dirt created by the higher firing rates. In order to maintain and even increase production rates, something had to be done at the Lackawanna plant to keep the checker flues open. Pitch has always been recognized as a superior fuel, but the problem of plugged checkers and flues resulting from its use was a serious handicap. At No. 3 open hearth, pitch has been used for about 10 years, but it was not until 1951 that the problem of keeping checkers cleaned was satisfactorily solved.

Prior to 1951, the responsibility of seeing that the checkers were cleaned regularly and properly in each open hearth was the labor foreman's, who had a crew of checker blowers under him. Due to the labor foreman's many other duties, his follow-up on checker blowing was at the best none too good; and his only guide on what needed to be done and what had been accomplished in cleaning the checkers was the complaints when a furnace did not draft properly. The result was that the checkers became plugged with flue dirt so that the furnaces drafted and operated poorly early in the campaigns.

In 1951, the responsibility of keeping the checkers

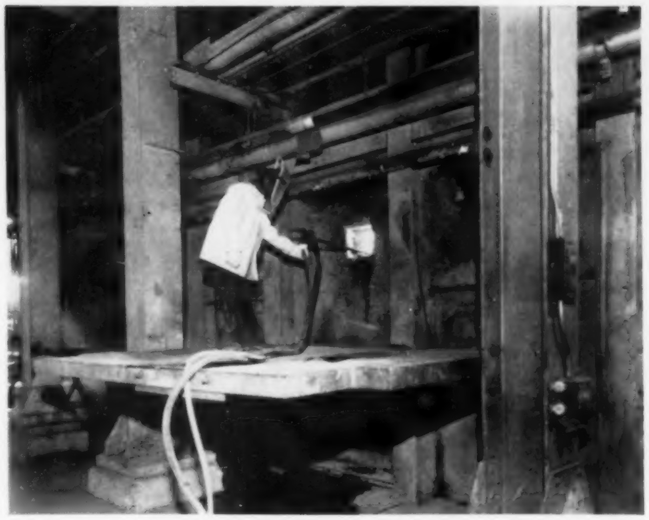


Figure 1 — The use of pitch as a fuel increased the problem of plugged checkers.

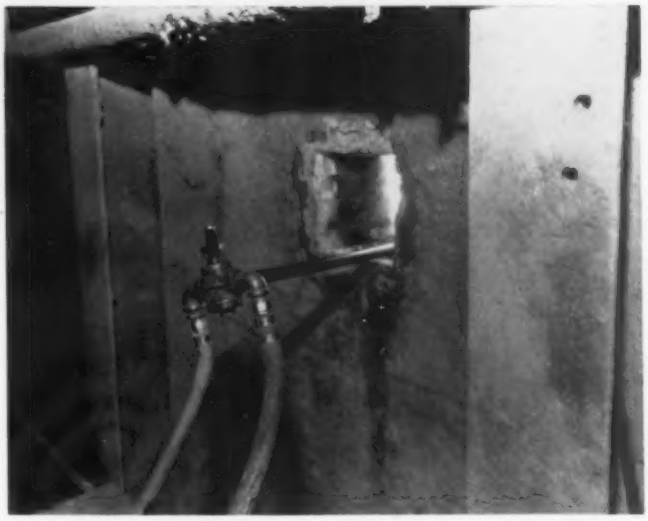


Figure 2 — A combination of water and compressed air is used on the hot passes and single passes where the fuel is pitch.

clean and slurried was taken away from the labor foreman and given to a general foreman of checkers and slurrying with supervision over all three open hearth shops, and a checker foreman in each shop. These men in turn are under the direct supervision of the assistant to the superintendent of open hearths. Deciding from the start of this new program that the cleaning of checkers should not be a hit-and-miss affair as in the past, a schedule for cleaning the checkers was set up and this schedule is strictly adhered to. Furthermore, all furnaces have to be blown regularly from the start of the campaign and not from the time they begin to show sign of becoming dirty. Once a furnace appears to have become plugged, it is generally too late to get it clean again. It is much simpler to keep a checker clean than to clean it after it has become dirty. It was also realized that some daily check on the condition of each checker and the effectiveness of the work of the checker blowers was necessary to detect any furnace that was not being cleaned properly.

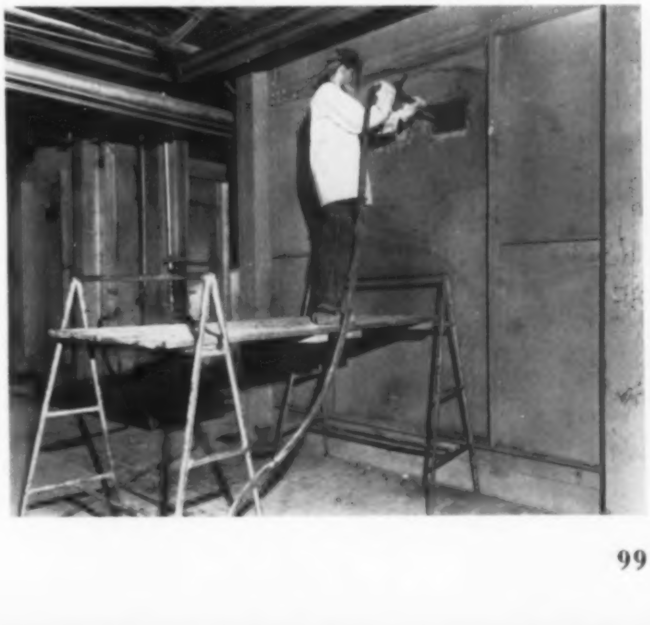
A schedule was consequently worked out for the various furnaces, based on the performance of the furnace draftwise throughout the campaign and by a visual inspection of the checkers before they were cleaned by the foreman when the furnace was down for rebuilding. The checker blowers assigned to a furnace were taken into the checkers so they could see for themselves how well they had kept the furnace clean and what mistakes, if any, had been made. This practice paid great dividends in teaching the blowers how to keep the checkers clean. From this visual inspection many things came to light, such as blind spots in the chambers where the blower could not reach with his pipe, and the depth of the dirt plug in the flue, which would indicate the proper length of "gooseneck" on the blowing pipe. These items were corrected as they were found.

From information gained by watching each furnace closely, and by classifying it as to type of checkers and type of fuel used, the following schedule was developed and is now being used: The hot-pass checkers on furnaces fired with pitch in any amount are blown twice a week, the cold passes once a week. Single-pass checkers on furnaces fired with pitch must be cleaned twice a week, while single- or double-pass checkers on oil-fired furnaces require blowing every seven days. It is an interesting fact that in using 30 per cent pitch on a furnace or firing with 100 per cent pitch the amount of flue dirt deposited in the checkers seems to be the same. On the 300-ton furnaces at No. 2 open hearth both the hot- and cold-pass checkers are blown twice a week. This blowing involves approximately forty man-hours per week on double-pass pitch-fired furnaces, thirty-two man-hours per week on single-pass pitch-fired furnaces and sixteen man-hours per week on double- and single-pass oil-fired furnaces.

To enable the foreman to know if the furnace checker needs to be cleaned out and how well they were cleaned by the checker blower, a set of draft readings showing the drops between the various stages of the checkers is taken every day on pitch-fired furnaces, and at least once a week on oil-fired furnaces. These draft readings are invaluable in helping the foreman to keep his checkers clean.

To clean the checkers, one-inch diameter pipes of various lengths, with an eighteen-inch gooseneck, are used. The length of this gooseneck varies up to as much as three feet if the checker flues show signs of being plugged down deep. Through these pipes, a combination of water and compressed air is used on the hot passes

Figure 3 — A 1-in. diameter pipe of various lengths is used to clean the checkers.



and single passes where the fuel is pitch. The blower opens the water side of the three-way valve and lets in enough water to fill the pipe, and then he opens the valve to the air side. Air at 80 psi drives the slug of water down into the flue, and if the flue is plugged, the water hits the hot flue dirt, is converted into steam and with a minor explosion drives the dirt out of the flue. To obtain the best results the checkers should be hot and care should be taken not to cool them by using too much water. If such care is taken, the method will keep checkers clean on pitch-fired furnaces. Compressed air alone is used on all cold passes and on double- and single-pass checkers where straight oil is the fuel.

No checker-blowing method can be successful unless the sewers underneath the checkers are kept clean. In fact, unless the sewers can be kept clean it is better that the checkers be not cleaned, as the dirt blown down into the sewers soon builds up to a point where the passage of waste gases is cut off. When this happens, the furnace is in bad shape. This was the problem facing us at Lackawanna on the pitch-fired double-pass furnaces after approximately 100 heats and on the oil-fired furnaces after approximately 150 heats. The sewers on the single-pass furnaces can be cleaned by removing the dirt by manual methods. This is done by locking the furnace at one end from the start of charging until the addition of the hot metal, removing the manhole covers on the incoming end in front of the checkers, and going into the sewers. The dirt is then shoveled into a bucket which is raised to the ground level with an air hoist. In this way it takes 10 to 12 men approximately three hours to clean the sewers on one side of the furnace. The two-pass checkers cannot be cleaned this way because the mound of flue dirt that restricts the flow of gases is away from the cleanout well, towards the idle pass. To clean the flue dirt the men would therefore have to go under the rider arches, an unsafe practice.

Over the years, various methods were tried in order to clean these sewers of flue dirt during operation, including steam agitators or soot blowers of various designs and a vacuum system to suck the flue dirt out of the sewers; but not until the present system was developed was the problem of keeping the sewers clean underneath the checkers solved. The present agitator system or soot-blower system, as some call it, consists of a two-inch diameter pipe run from a common header to a cast iron nozzle which is installed in the middle of the sewer, 9 to 12 in. above the floor, and insulated. This nozzle is 9 in. long, with a 1¼-in. diameter hole reduced to a 5⁄16-in. diameter throat one inch back from the tip. From the 15⁄16-in. throat, the hole is opened up on 7½ degree taper to the tip. The steam supply for the agitators is taken from a 150-psi header which gives a pressure of approximately 80 psi at the nozzle when one agitator is used, and from 65 to 70 psi at the nozzle when two agitators are blown at the same time.

There are three standard types of installations used on the various types of checkers. On single-pass checkers where oil is used as a fuel, one agitator is installed in each sewer eight feet back from the front of the checker. On the single-pass checkers when pitch is used as a fuel, two agitators are installed in each sewer, one at the back of the sewer towards the slag pocket and one eight feet back from the front of the checker. On all double-pass checkers, regardless of the fuel used, two agitators are installed in each hot-pass sewer, one in the well at the idle pass, pointed towards the slag pocket, and one through the bulkhead at the back of the hot-pass sewers, pointed towards the stack. In the cold pass, one agitator is installed in the back of the sewer, pointed towards the stack. On furnaces having extra long hot-pass sewers, like our 300-ton furnace, an additional agitator is installed in the middle of the sewer, pointed towards the stack. These agitators are blown twice a week on the single and double-pass oil-fired furnaces, and every other day when pitch is used as fuel. The agitators on the 300-ton furnaces are blown every day for approximately five minutes.

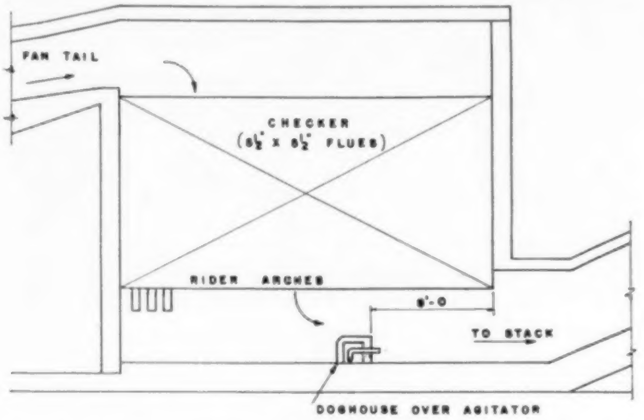


Figure 4 — Sketch shows single pass checker agitator on oil fired furnace.

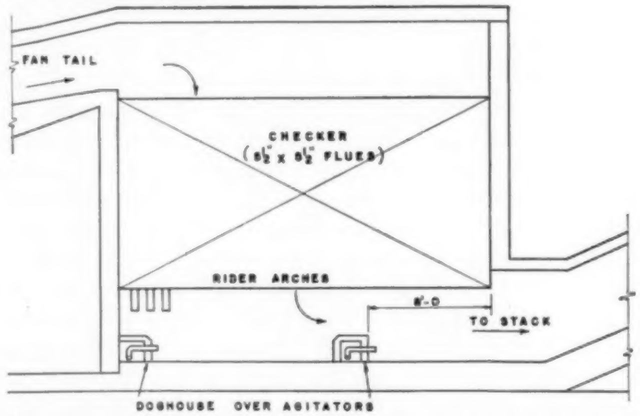


Figure 5 — Sketch shows single pass checker agitator system on pitch fired furnace.

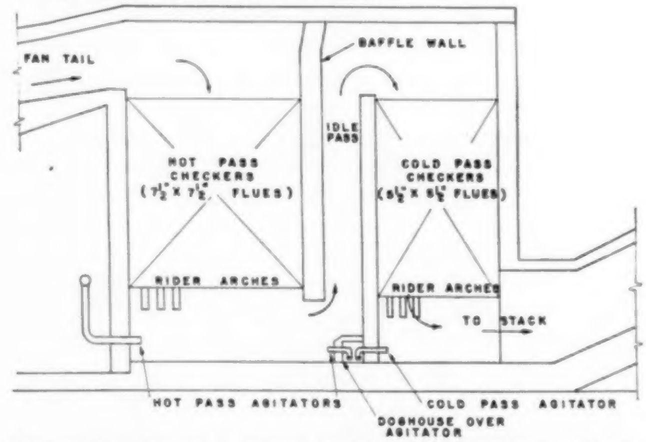


Figure 6 — Sketch shows double pass checker agitator system.

This system of sewer cleaning has worked quite successfully and the sewers are kept clean at all times. Occasionally a pipe will break in a place where it cannot be repaired until the furnace is down for repair, but generally the system has been quite reliable. The agitators are a great help in cleaning checkers during rebuilding of furnaces. Formerly the hot-pass sewers had to be cleaned before the checkers could be cleaned, because there was no place to put the dirt from the checker flues. The sewers then had to be cleaned again after the checkers were cleaned, causing delay and additional cost. Now the sewers are cleaned once during rebuilding, after the checkers are cleaned.

Proper maintenance of checkers is a must if maximum production is to be obtained from open hearth furnaces. The furnace may be drafting properly and still be suffering from the effect of lower preheat of the combustion air due to dirt deposits on the walls of the checker flues. This dirt insulates the checker brick and prevents transfer of the heat in the waste gases to the brick and conversely from the brick to the combustion air. Since air can only be heated by contact, the surface of the checker brick must be clean if maximum heat transfer is to be obtained. The loss of draft in the checker system and the usual inspection of the tops are our only ways of finding out how well the checkers are kept clean; however, quite a few flues in the checker system may be plugged without changing the draft loss appreciably. This plugging of flues cuts down the total heating area available to heat the combustion air and the free area. This increases the flue velocity, giving the air less time of contact with the checker brick.

The success or failure of any checker cleaning program depends on how well the smallest details are followed up. Keeping the checkers clean on a pitch-fired furnace is a never ending job, and constant checks must be made to see that everything is in order. Each furnace campaign is a challenge to the foreman and his blowers because the conditions in the checkers are constantly changing. One time the tops of the checkers are collecting heavy deposit of dirt, shutting off the draft; the next week the flues may be plugging down deep. Only experience can tell because the interior of the flues cannot be seen and can only be guessed at until the furnace is down for rebuilding.

The use of water and air to blow the checker openings and the installation of the present type of agitators to blow the sewers under the hot and cold-pass checkers, coupled with much closer supervision, have furnished the solution to the checker problem at Lackawanna.

Each furnace, as well as each shop and plant, has its own individual peculiarities. What has worked for us might not be the answer to someone else's problems; but the basic idea of regular checker blowing under good supervision, with the proper follow-up, will keep the checkers clean and the open hearth furnaces operating at peak efficiency.

DISCUSSION

PRESENTED BY

R. M. JORDAN, Assistant Superintendent, No. 3 Open Hearth, Bethlehem Steel Co., Lackawanna, N. Y.
FRANK S. SWANEY, Assistant Combustion Engineer, Jones and Laughlin Steel Corp., Pittsburgh, Pa.
HARRY C. PAXSON, Assistant to Superintendent Refractories and Fuel, Lukens Steel Co., Coatesville, Pa.
EDWARD E. McGINLEY, Division Superintendent Open Hearth, United States Steel Corp., Munhall, Pa.

Member: I have two questions: What is the change, if any, in maximum checker temperature readings from the start to the finish of a furnace campaign? As a result of your method of cleaning checkers, what is the vertical lift in the dummy pass of your multiple pass checkers at Lackawanna?

I think that it is quite remarkable that you are able to lift the disturbed accumulation of flue dust at the bottom of the hot pass, and at the bottom of the dummy pass up vertically some 16 or 17 feet to where the dust flow runs through the cold pass.

R. M. Jordan: We have a maximum temperature in our open hearths of 2450 F and our temperature is recorded. We insist that our checkers stay below this 2450 F. We try to go as hot as possible without burning the checker brick. On the day we blow the checkers, our temperatures will drop to around 2100 F. Most of that is from the opening of the checker blowers. You have to give the man access to get in and blow his checkers which allows cold air to be drawn in.

On the second question, we were lifting the flue dirt approximately 15 feet.

Member: On the first question, you no doubt take your temperature readings near the bridge wall?

R. M. Jordan: Yes.

Member: If you were running temperatures at 2450 F in the early stages of the campaign; at the tail end of the campaign, would you still maintain that temperature?

R. M. Jordan: For the most part, they do not change appreciably from the beginning of one campaign to the other. That is a must in the furnace operation. We must keep the infiltration down and we do that by repeated checks.

Member: What is the steam pressure on your steam agitators?

R. M. Jordan: It is not what we would like it to be. We have 150 psi in the main line, and the best we can get is about 80 psi at the nozzle. At a higher pressure, we could do an easier job, and could possibly cut down the blowing time.

F. S. Swaney: Mr. Jordan has presented an excellent account of a steel mill operating problem that is typical of many encountered almost daily as the press for more and more production creates new bottlenecks or reveals limitations in existing equipment.

The paper just presented indicates that the problem of maintaining clean checkers at Bethlehem's Lackawanna plant has been recognized, analyzed, and solved in quite a workmanlike manner.

It is believed that one of the most important factors in the success of such a checker cleaning program is the placement of responsibility. One foreman, who has been assigned the job of keeping all checkers clean and tight, and who has the necessary personnel to perform the work, cannot but do a better job than one or more foremen who are also burdened with sundry other duties. It would seem this is a case of justifiable specialization.

Another feature that is highly commendable is the practice of having the checker blowers themselves inspect the checker condition when the furnace is down for a rebuild. Such a practice will invariably stimulate employee interest and result in better, more intelligent job performance.

Mr. Jordan's statement regarding the equal checker buildup at both 30 per cent and 100 per cent pitch firing rates is most thought provoking and would merit some clarification if he would care to do so.

It is indicated in this paper that much use is made of daily checker pressure drop checks. Since this could prove quite time consuming to do daily on each end of a number of furnaces, the question naturally arises — is this done with portable or with permanently mounted equipment?

As described, the checker brick are blown with compressed air on oil fired furnaces and with water on pitch fired furnaces. Perhaps Mr. Jordan will explain why the difference and also what his thoughts are regarding the use of steam for this job.

The soot blowers installed in the checker sewers make use of a steam jet of specially designed dimensions to achieve a venturi-type throat. Are the results obtained from this construction superior enough over a drilled hole to justify the additional machining required?

In closing, Mr. Jordan and his associates are to be commended on a checker cleaning program that is well thought out, intelligently applied, and carefully followed up.

R. M. Jordan: As far as the amount of dirt made when we fire 100 per cent pitch or 30 per cent pitch, it is my observation and I have not measured it in any scientific way. Several years ago we at Lackawanna went to what we call dual fuel firing whereas we used to fire 100 per cent pitch in our No. 3 open hearth and the rest had all oil. We split it up at first on a 60-40 basis, 60 per cent pitch and 40 per cent oil, and then we got down to 50-50, and then we finally got to about 60-40 combination. This is on dual fuels which are 60 per cent oil and 40 per cent pitch. We hoped by cutting the amount of pitch down that the problem would be simpler. We did not find it so. We found checker cleaning just the same problem as when we used 100 per cent pitch.

We are now firing 30 per cent pitch, and our checkers get just as dirty and it takes just as much attention to keep them clean.

We have a special man, who takes our draft readings. It is done by a portable draft gage, and it is not very time-consuming. We have, normally, ten-minute reversals, and he can take it within the ten-minute reversals.

Every day these readings pass over the foreman's desk and he uses them very religiously. It is not always the fault of the checker blower that the drafts are bad, it might be a hole in the fan tail or that somebody left an agitator turned on, or that the first helper is pulling his furnace too cold. We have a certain standard, and if we see any deviations from that standard, we check it.

On steam blowing of checkers, we have tried quite a few different ways of blowing checkers. We have used steam, cross flues, air, and we have used a combination where we had a steam pipe flowing down and the air pipe blowing up because a man could not hold the pipe down with the high steam pressure. It was quite a bulky thing but it worked. We found after a period of time with cross flues, they filled up with dirt. The flue dirt would gather in the cross flues rather than blow through like a solid flue. Over a period of a year and a half, we involved water and air which is now a standard practice. There are certain specified times when maybe one would be better than the other, but generally speaking, water and air are the simplest and best methods in blowing checkers.

We started out with trying just straight one-inch holes and it worked fine and then we got the idea, of using the venturi. I might add it takes a lot of technique to operate these agitators. You cannot just put them in and turn them on. The angle in which they strike the pavement and the frequency of blowing, and the method of blowing all has to be worked out which takes time.

We went on this venturi-type nozzle and that is what we used.

I dare say that you can use a straight type and get along very nicely.

Harry C. Paxon: Do you have waste heat boilers?

R. M. Jordan: Yes, most of our furnaces are equipped with waste heat boilers.

Harry C. Paxon: Have you blown the soot from the flue out to the waste heat boilers and did it result in extra time in cleaning the boilers, or does it all pass through and go up the stack?

R. M. Jordan: Apparently, by the time we get it out to the sewers, it is fine enough that the draft fan water carries it up the stack. We have not noticed any appreciable increase in the amount of dirt left in our sewers in our checkers to our boiler, but what goes out of the cold pass, goes up the stack.

Harry C. Paxon: Were you saving time one place and having to use additional manhours someplace else?

For example, we have tried the same thing in our plant and the soot blower has worked fine. We have moved the soot out to the boilers and the results were that we have extra time in cleaning the boiler. Instead of cleaning it once a week, we go down three or four times a week for cleaning.

R. M. Jordan: I cannot say for sure whether our blowing frequency of boilers has increased, but I do not think it has. We have noticed more erosion on our turbine drive on our draft fan.

Edward McGinley: I would like to ask Mr. Jordan one question relative to the horizontal openings in this second pass. I noticed only one such opening. Are there other horizontal openings at lower elevations?

R. M. Jordan: We have eliminated what we call cross-flue horizontal openings practically entirely.

What you want is that velocity to carry into the sewer, and any time you have an opening, that will let the velocity and pressure dissipate.

We have to clean down deeply and you can only use a gooseneck to certain lengths. You have to depend on your velocity and any cross flue will dissipate that velocity and keep you from cleaning. We have found from our own experience that we clean right from the top and that way we do a much better job.

Preliminary Program

ASSOCIATION OF IRON AND STEEL ENGINEERS

1954 AISE CONVENTION
AND
IRON AND STEEL EXPOSITION

CLEVELAND PUBLIC AUDITORIUM
CLEVELAND, OHIO

September 28, 29, 30, October 1

Tuesday, September 28

9:15 am — Business Meeting

9:30 am — Electrical Session

Electrical cables for steel mills.
Methods for locating faults on electrical cables.
Communication practice in the steel industry.

9:30 am — Blast Furnace Session

Rapid method of relining blast furnaces.
Extending blast furnace life after hot spots appear.
Washer for blast furnace gas.

2:00 pm — Mechanical Session

How and why to reuse industrial cooling water.
Eliminating losses due to fires.
Maintenance of mobile equipment in the steel plant.

2:00 pm — Combustion Session

Modern open hearth furnaces.
Open hearth waste gas analysis control.
Soaking pit operation.

10:00 pm — President's Dance

Wednesday, September 29

9:00 am — Electrical Session

High capacity third rail systems.
Effect of shape of crane wheels on alignment during operation.
Protective devices for material handling bridges.

9:00 am — Combustion Session

Comparison of calculations and furnace performance test data on rate of heat absorption in steel.
Continuous batch type annealing furnace.
High thermal release burners and their application.

2:00 pm — Steelmaking Session

Control of arc furnaces.
Making steel by blowing oxygen in a converter.
Effect of ferro-manganese additions in the open hearth.

2:00 pm — Lubrication Session

Non-flammable hydraulic fluids.
Stability of lubricating greases.
Improvement in greases.

6:00 pm — Old Timers' Dinner

Thursday, September 30

9:00 am — Electrical Session

Designing transformers for the steel industry.

Control of kilovar, kilowatt and voltage in steel plant electrical systems.

Synchronous condensers.

9:00 am — Lubrication Session

Modern techniques in applying lubricants to old mill equipment.

Maintaining bearings.

Failures in plain bearings.

2:00 pm — Protective Coating Session

Painting in the iron and steel industry.

Protective coatings in coking plant areas.

Color selection in paint.

2:00 pm — Operating Practice Session

Continuous casting.

Scarfing.

Progress and applications in the use of titanium.

7:00 pm — Formal Dinner and Dance — A speaker will give an interesting and humorous lecture relating some very unusual travel experiences.

Friday, October 1

9:00 am — Rolling Mill Session

The planetary hot strip mill.

The new 11-in. rod mill at Aliquippa.

Causes of roll breakage.

9:00 am — Combustion Session

New power plant at the Ohio Steel Works.

Making and using power plant records for management.

Gas mixing equipment.

2:00 pm — Electrical Session

Magnetic amplifier control on tandem cold mills.

Maintenance and repair experience with hydraulic systems on charging machines.

Developments in d-c motor design.

2:00 pm — Operating Practice Session

Detecting pin holes in sheet.

Continuous drawing of cold finished bars.

Cold roll forming.

IRON AND STEEL EXPOSITION

The Iron and Steel Exposition will set new records in booth space and number of exhibitors who will be present at this bi-ennial exposition of the Association of Iron and Steel Engineers. Approximately 200 exhibitors will be represented in 409 booths which will require the full capacity of the Arena, Exhibit Hall and North Hall of the Cleveland Public Auditorium. The latest developments in steel plant equipment and processes will be shown at this time. Exhibit hours are as follows:

Tuesday, September 28	**10:00 am — 10:00 pm**
Wednesday, September 29	**10:00 am — 10:00 pm**
Thursday, September 30	**10:00 am — 5:30 pm**
Friday, October 1	**10:00 am — 4:00 pm**

REGISTRATION

Registration for both the Convention and the Iron and Steel Exposition will be held in the main lobby of the Cleveland Public Auditorium. Hours for registration are the same as the exposition hours.

HOTEL ACCOMMODATIONS

Hotel reservations should be made direct to the hotel of your choice giving time of arrival and type of accommodations which are desired. Reservations should state that they are for the AISE Convention and Iron and Steel Exposition. If they are unable to take care of you, they will forward your request to the Cleveland Convention Bureau, who will place you elsewhere. The Hotel Statler is the headquarters hotel for the social activities.

MISCELLANEOUS

No inspection trip is scheduled for this convention.

Final program giving detailed titles and authors names will be mailed within the next month.

SOCIAL FUNCTIONS

Social functions will take place at the Hotel Statler which is the hotel headquarters for this convention. All other events will be held in the Cleveland Public Auditorium.

TRENDS IN RECENT COLD MILL INSTALLATIONS

By R. E. NOBLE
Engineer
Rolling Mill Dept.
Mesta Machine Co.
West Homestead, Pa.

. . . . rolling mills have finally caught up with the operator's demands for speed and power . . . .

▲ IN the rolling of flat steel products on four high mills there has been a fairly steady advance in many directions since the early days of this revolutionary development some twenty-five years ago. This advance has been manifest in increased rolling speeds, higher powers and heavier coil weights. The top speeds of tandem cold mills for light gages have recently been pushed well beyond 6000 fpm. Though speeds on this order have not yet been fully exploited, the actual sustained rolling speeds now used are not far enough below the top speeds to indicate that the ceilings of these new mills have been pushed much too high.

The first tandem four high cold mill for tin plate gages was built in 1928. The speed of the mill at the base speed of the motors was 114 fpm, its top speed was 342 fpm and the total rated power for the main drives and reel was 1090 hp. One of the latest tandem tin plate mills has a top speed of approximately 7000 fpm and a total of over 21,000 rated horsepower. Between these extremes lies approximately a quarter century of progress and experience in cold rolling.

The upward trend in speed in the rolling of tin plate is shown graphically in Figure 1. This diagram lays no claim to any great accuracy or completeness but it shows better than a tabulation, the long upward climb.

It is not surprising of course that the continuous cold rolling of flat products should first have been undertaken at low speeds. Such experience as was available from the cold rolling of steel in sheets or narrow strips in two high mills did not afford much promise of high production rates in cold rolling.

The successful reduction of flat rolled products to relatively light gages by the continuous strip rolling process necessarily awaited the development of a good "backed-up" mill such as the four high mill.

It was soon found that tension between tandem cold mill stands (or between reels and mill in the case of the reversing cold mill) played a very important part in the reducing process. Another factor of great importance in cold rolling to light gages is the necessity for lubricating the strip in the bite of the rolls to reduce the friction to a minimum at the point where the elongation of the strip results in a slip or a differential in speed between rolls and strip.

In the conventional tandem reducing cold mill, the strip is threaded at comparatively low speed and entered into the winding reel. Tension is established and maintained between stands and between the final stand and the reel, and the entire train is accelerated to the predetermined rolling speed while maintaining tension as well as possible during the acceleration period.

Deceleration is accomplished also while maintaining tension and all the elements of the mill train come to rest together when the coil is completely wound on the tension reel. In the case of the reversing cold reducing mill similar conditions prevail. During intermediate and final passes front and rear reel tension is maintained as well as possible, and the coil is wound first on one side of the mill and then on the other between reversals.

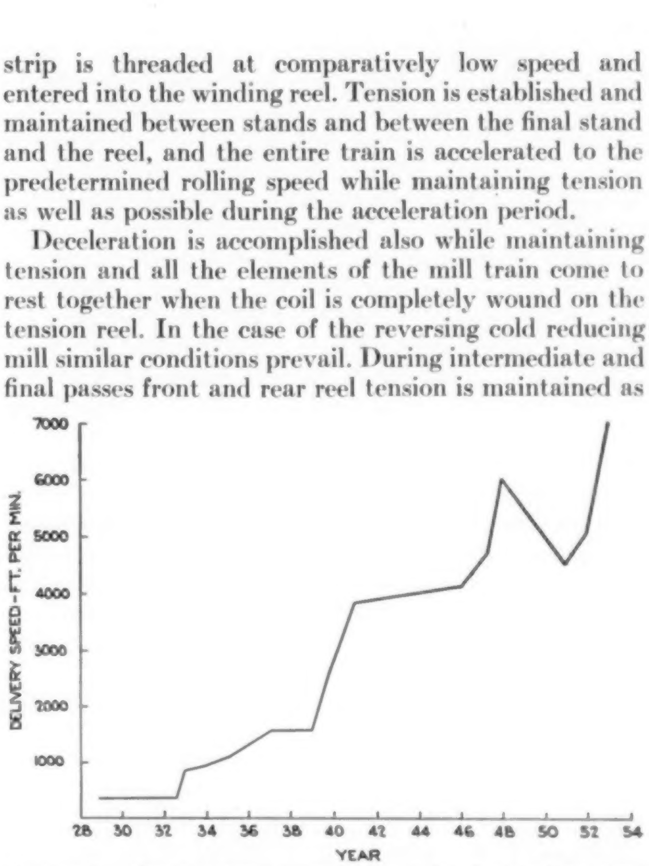


Figure 1 — Curve shows speed trends for 5-stand tandem cold mills.

In the early days of continuous cold rolling, comparatively low speeds were taken for granted. It was not immediately apparent moreover what the limiting considerations might be or what factors would have to be considered if speeds were to be increased. We may now examine, however, in the light of experience certain important factors which have to be considered as speed, power and coil weight increase.

Perhaps one of the most fundamental is heat removal; that is, control or limitation of temperature in rolls and strip. The total heat developed in cold rolling is evidently the heat equivalent of the external work applied to the rolls. A brief consideration of what goes on in the mill will be sufficient to show that this is true. The friction and plastic deformation that occur in the bite of the rolls very evidently produce heat. The total energy in ft-lb, or kilowatts applied to the rolls must appear somewhere as heat as fast as the mechanical energy disappears, as that is the only way the dissipated mechanical energy can be accounted for. With the increase of speed and power, the cooling system of course becomes increasingly important.

The importance of proper roll and strip lubrication can scarcely be overemphasized as a factor in successful rolling particularly at high speeds. Roll cooling and roll lubrication are so intimately associated that one can not be considered without the other. Various kinds of rolling lubricants are used in connection with water as a cooling medium. These may be broadly classified as those soluble in water and those insoluble in water.

As a rule the rolling of the heavier gages presents less difficulty with respect to both cooling and lubrication than the rolling of light gages such as tin plate, which are usually rolled at the highest speeds. In rolling the heavier gages, water cooling with the application of a very small quantity of mineral oil to the strip is usually sufficient. Where soluble oil is used, a water and soluble oil solution is recirculated and so used over and over with suitable filtering and cooling.

In the rolling of tin plate two systems have developed side by side. In the one a mixture or emulsion of water, soluble oil, palm oil and a little mineral or engine oil is supplied to the mill. It is prepared by initial heating and agitation and after returning from the mill is recirculated usually through some filtering and cooling units to control heat and cleanliness as well as possible. When dirt and contamination accumulate to a certain point, the batch is discarded and a fresh mixture is made up. With this system the same medium is used for cooling and lubrication. The coolant goes to the mill and is sprayed into the bite of the rolls at a fairly high temperature (about 160 F) and the mill operates at a fairly high temperature. The system is quite economical with respect to the use of lubricant.

In the other system, water is used as the cooling medium and palm oil or a water and oil mixture is applied to the strip as a lubricant before it reaches the bite of the rolls. The main reliance has thus far been on palm oil. Other lubricants have been used. It is to be hoped that our present dependence on palm oil will not continue indefinitely. The price of palm oil has fluctuated widely and the cost at times can be quite a serious element in the total rolling cost. The economical application of palm oil is therefore of considerable importance and the effective use of it is important to satisfactory rolling especially at high speeds.

We may consider three to four pounds per ton of steel to be a good economical figure. When rolling tin plate of 32 gage or 0.010 in. thick at this palm oil rate, a pound of palm oil must be spread as evenly as possible over 2400 to 3200 sq ft of surface, top and bottom, based on the area of the strip as it finally emerges from the last stand. When it is considered that three or four applications of palm oil are made between the stands of a five-stand mill (though before full elongation is accomplished) it is evident that the oil must be spread pretty thin.

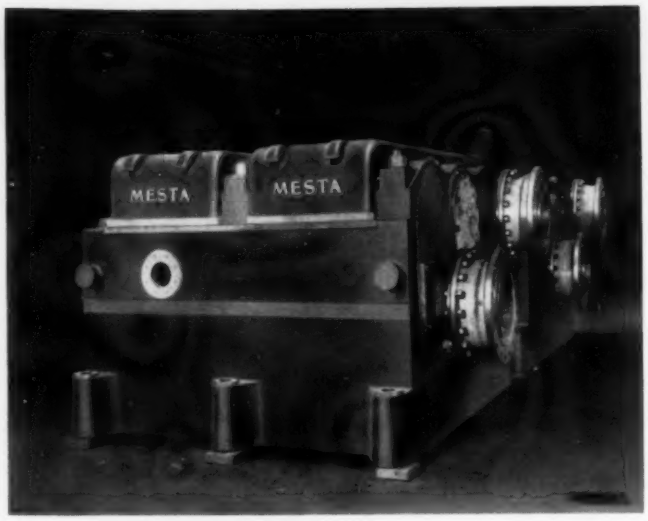


Figure 2 — Twin motor drives for 56-in., 4-stand tandem cold mill.

In order to increase the volume for better distribution, the palm oil is now usually mixed with water to form a somewhat unstable mixture or emulsion of three or four parts water to one part palm oil. The application is made through fine spray nozzles throwing a flat, finely divided spray from an orifice with an equivalent area corresponding to a diameter of 0.025 to 0.040 in. The effect of dilution with water is therefore to allow a larger orifice than would otherwise be possible for economical distribution, with less chance of clogging.

The palm oil emulsion is made by proportioning pumps delivering to a small mixing tank. Water is fed to the tank at about 175 F and palm oil at a temperature twenty-five or thirty degrees lower. The mixture is circulated in a closed loop which returns to the tank. The liquid must be constantly kept in motion at a good velocity to avoid separation. The loop must be kept warm by suitable insulation and is usually steam traced.

From the loop the mixture is fed to manifolds at the mill by individual rotary gear type displacement feeder pumps driven by adjustable speed motors. At the manifolds, remote control three-way valves allow the pump delivery to be by-passed back to the tank when the mill is standing or being threaded, to avoid waste of palm oil. This system has proved to be quite satisfactory and economical even at very high speeds.

Another factor to be considered in very high speed mills is the matter of acceleration and deceleration. It is difficult to maintain uniformity of gage at varying speed, even if the tension is well maintained and this results in an unavoidable tendency toward off gage product while the mill is accelerating and decelerating. There is therefore the need to reduce the accelerating and decelerating time to a minimum to limit the footage of off gage strip and this means high accelerating and decelerating rates. The effect of larger coils is of course to reduce the *percentage* of strip rolled at varying speed by allowing the mill to roll longer after a constant speed is reached. This and the desire to reduce the *percentage* of time used in threading have been major reasons for the trend toward heavier coils.

The increase in speed of modern cold mills has made the gaging of thickness more difficult as the higher speeds are beyond the capability of contact gages which depend for their effectiveness on keeping a pair of small rollers in contact with the strip. We are therefore forced into greater dependence upon non-contact gages such as x-ray and other similar gages.

Besides the effect of increased speed with respect to the more general considerations just discussed, the adaptability to high speed of a number of the details of the mill proper and drive must also be considered. Most modern mills run on oil film back up roll bearings. At the speeds now attempted, we have encountered no trouble when the viscosity of the oil has been selected to suit the journal speed.

Work roll and back up roll thrust bearings are usually roller bearings. It is acknowledged that it would be better to lubricate high speed roller bearings with oil, but grease is much more convenient on account of the frequency of roll changing. We have encountered no difficulty in running these bearings on grease but the running clearances must be increased beyond what would be considered normal for bearings running at lower speeds.

The rotative speeds of the work rolls in the high speed stands in recent tin mills have in some cases outstripped the speeds of the driving motors. There is a practical limit to the speed of large motors with respect to the product of speed and power which can be designed into a single armature. Recent high speed mills have therefore resorted to speed up drives with speed ratios as high as one to two, motor to rolls (see Figure 2). An additional feature of these drives is that since multiple armatures are necessary anyhow, there is an opportunity to drive each work roll with a separate motor.

One aspect of the modern high speed cold mill installation that should be mentioned here is the increasing importance of what we may call the auxiliary services. Besides coolant and roll and strip lubricating systems which we have discussed, these include the following items:

Lubricating systems.
Hydraulic roll balance systems.
Auxiliary hydraulic power systems.
Fog exhaust systems.

All these are necessary to the satisfactory and dependable performance of the mill and the demands upon them have steadily become more and more exacting.

The great increase in coil weight has resulted in a corresponding increase in the capacity and total power requirement of the auxiliary hydraulic power service which is needed mainly for the handling of coils at the entry and exit ends of the mill. These systems like the roll balance systems must be highly dependable. Triplex plunger pumps are preferred, and for auxiliary hydraulic power either weight loaded accumulators or hydro-pneumatic pressure vessels charged with air or inert gas.

In many mills, particularly those using coolants that combine the cooling and lubricating functions in one medium, the vapor or fog that is developed around the mill stands necessitates the partial closure of the stands with hoods and baffles that leave openings between stands just large enough to allow entry of the operators for threading and guide maintenance. The partially enclosed spaces between and around the stands are then connected to an exhaust fan system which draws off the vapors with the air that enters between the stands. The inward currents of air then help to prevent the escape of oil vapors to the mill building.

The fan system usually discharges through a baffle type separator into a vertical stack of liberal area and height where vapors escaping the separator have a chance to condense and drop back so that the discharge at the top of the stack is as free as possible of oil and water vapor.

As coil weights have increased, the subject of coil handling and coil handling equipment has assumed greater importance. This includes not only the methods of transporting coils between departments and to and from the mill, but also the means of handling coils at the entry and delivery ends of the mill including preparation and presentation of the leading end of the strip to the bite of the rolls, threading through the mill, engagement on the winding drum, and final stripping and discharge of the coils from the reel.

In the pioneer tandem tin mill mentioned earlier in this paper, the maximum coil size was 32 in. diam × 28 in. width weighing about 4000 lb. Recent installations including mills for sheet gages and widths have provided for coil diameters up to 72 in. and weights of 45,000 lb for tin plate and 60,000 lb for sheet gages.

The practice of welding two or more hot rolled coils together in the pickling line together with a moderate increase in the available weight of the hot rolled coils has made it possible to produce and roll through the cold mill, coils of any size that can be handled to and from the mill. Any increase in size and weight of coil, however, affects all of the handling, feeding and coiling equipment on both ends of the tandem reducing mill, and throughout the rest of the cold mill plant. Coil size therefore is a matter of overall economy. Every increase in size and weight of coil is reflected in the bulk and cost of practically all the auxiliary equipment of the cold mill plant.

The equipment required for handling the coils at the entry and delivery ends of the tandem mill now usually comprises the following items:

Entry conveyor or ramp with stops.
Lowering and positioning rolls.
Feeding pinch rolls and coil box.
Tension reel with elevating stripper.
Belt wrapper.
Delivery ramp or conveyor with scale.

Early mills started with only the coil box, tension reel and stripper (without elevator) as the essential elements. Improvements and refinements have been made to these and the other items have been added as a matter of necessity with the increase in speed and coil weight.

Good facilities for handling coils weighing from 30,000 to 60,000 lb both at the mill and in interworks transport have become increasingly necessary and important.

Feeding the coil to the mill involves bringing it up to position on a ramp or entry conveyor, lowering it to coil box level, rotating it to present the leading end to the bite of feeding pinch rolls, and releasing it to the mill after the leading end of the new coil has been entered through open entry guides into the bite of the mill rolls.

At the delivery end, a belt wrapper is necessary to save time and effort in engaging the strip on the tension reel block and is used for all except the very heaviest gages. An elevating stripper which supports the weight of the coil while stripping, and discharges it to coil ramp or conveyor, completes the necessary equipment at the mill.

For moderate weight coils, ram tractors afford a convenient and flexible method for transport to and from the mill and between departments. For the heavier coils, however, ram tractors become quite bulky and cumbersome and wheel loads are pretty high on account of the cantilever loading of the coils on the tractor ram. As coil weights have increased, there has been a marked trend toward the use of driven chain conveyors to serve the mill at both entry and delivery ends and also for transport between buildings or departments. Weighing scales and upenders or downtilters are often incorporated as part of the conveyor system. Even where conveyors are not used primarily for transport, short runs at the entry and delivery ends of the mill serve as cushions or reserve storage for the benefit of crane or ram tractor service to and from the mill.

The following brief descriptions of several recent mills will illustrate most of the features which have been mentioned.

21 AND 53 x 42-IN. FIVE-STAND TANDEM TIN MILL
Jones & Laughlin Steel Corp.
Aliquippa, Pa.

This mill has had a great deal of publicity and its principal features are well known. See Figure 3. The mill has a top speed of 6000 fpm. The total rated power of the main drives and tension reel is approximately 17,000 hp. The maximum coil diameter is 72 in. The expanded reel block is 16 in. diameter. The first two stands are driven through conventional pinion stands, the last three by speed increasing drives of 1.5 to 1, 1.5 to 1 and 2 to 1 ratio respectively. On these stands top and bottom work rolls are driven by separate motors.

The mill stands are spaced 13-ft 0-in. centers to help keep off gage strip to a minimum and the housings are extremely rugged and heavy. As a result, the access width between stands is reduced to a minimum. Filtered water is used on the mill for cooling. Palm oil is used as a roll and strip lubricant applied as previously described in the early part of the paper.

Lubricating, roll balance and auxiliary hydraulic equipment is located in a cellar at the delivery end of the mill. Palm oil mixing equipment is also located in this cellar next to the mill and the palm oil piping loop and feeder pumps are in a tunnel under the mill spindles. The cooling water and oil discharged from the mill run through a flume on the working side of the mill into a 5-ft diameter well equipped with two vertical sump pumps of the submerged type, one of which is intended as a standby unit. These pumps have a head-volume characteristic that makes them self governing, the volume responding to the suction level in the sump. They pump the water and oil mixture through an 18-in overhead line to skimming tanks in an elevated structure some 700 ft away where the oil is skimmed and treated for recovery and the water is discharged to the river.

The mill is ventilated by two 80,000-cfm fog exhaust fans pulling the vapor downward through the floor and then through a baffle type separator. From there it is drawn through a tunnel to the fans located on a balcony and discharges through a vertical stack carried above the roof.

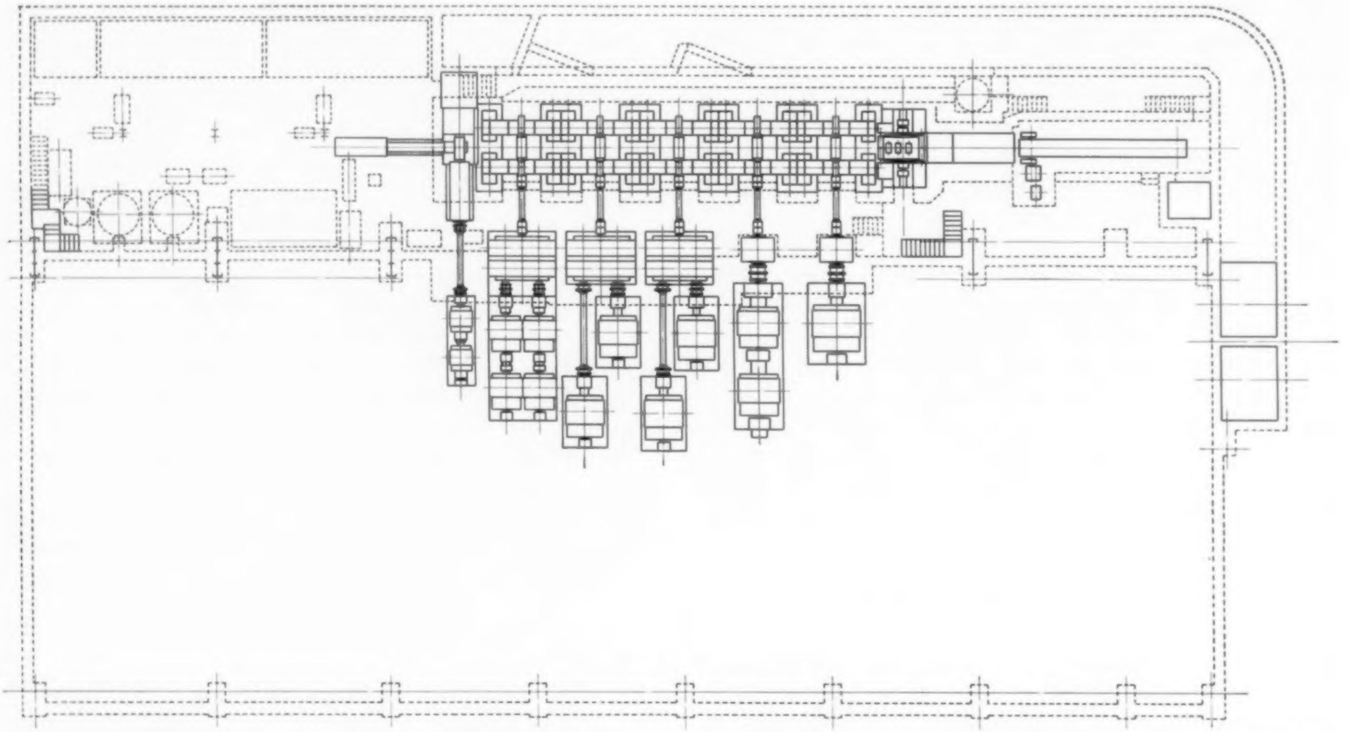


Figure 3 — The 5-stand tandem cold mill at Jones and Laughlin's Aliquippa plant was designed for a top speed of 6000 fpm

12 AND 26 x 24-IN. FOUR HIGH REVERSING COLD MILL
Kaiser Steel Corp.
Fontana, Calif.

This mill (Figure 4) is powered by a 1000-hp reversing motor 400/960 rpm at 600 volts. The mill is driven through a combination gear drive and pinion stand with a gear ratio of 2.64 to 1. The full voltage strip

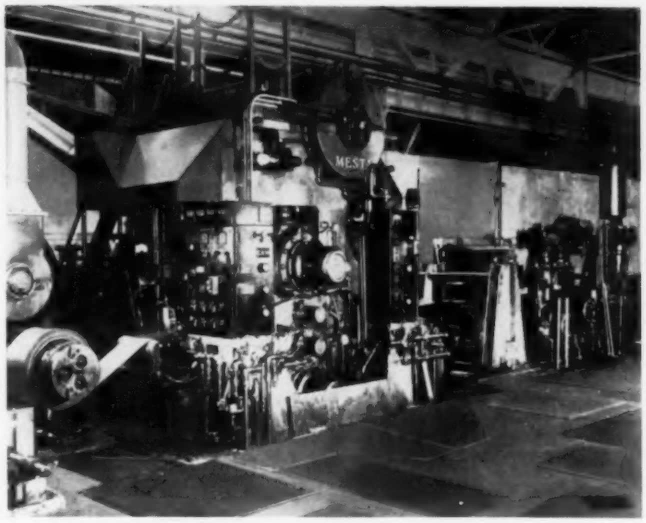


Figure 4 — This 12 and 26 x 24-in. reversing cold mill is driven by a 1000-hp reversing motor.

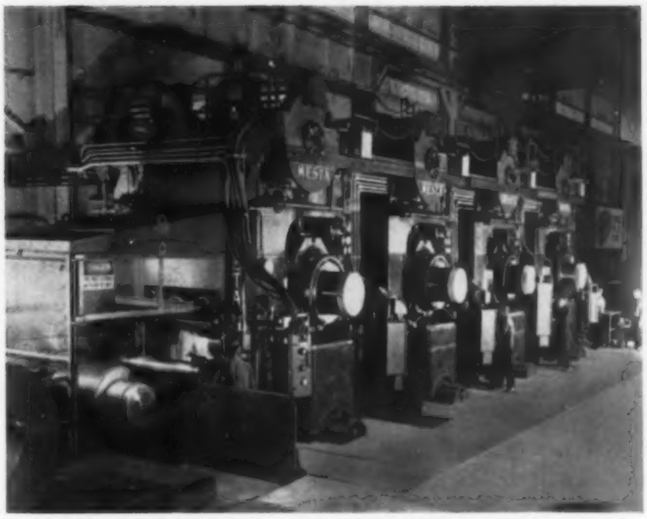


Figure 5 — All stands of this 4-stand tandem cold mill are driven through pinion stands without gear drives of any type.

speed with 12-in. working rolls is therefore 475 to 1140 fpm. The tension reels on both sides of the mill have 20-in. diameter collapsible blocks and are powered by 300-hp motors through single reduction gear drives.

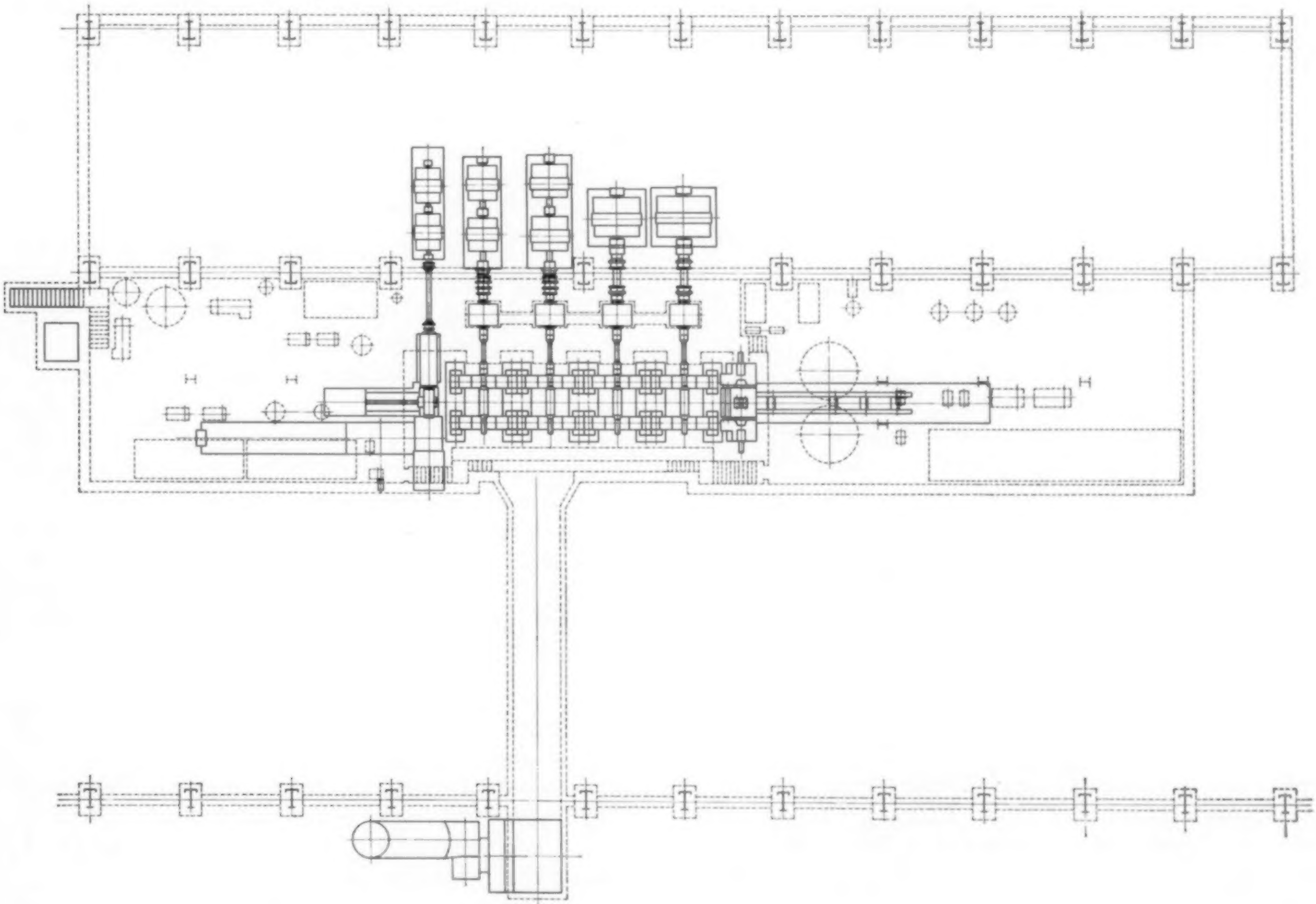
The top work roll and top back up roll of the mill are balanced by springs located within their respective bearing boxes. Picked coils are fed to the mill for the first pass from a coil feeder through pinch rolls and a three-roll straightener. Successive passes are wound under tension on their respective tension reels. The gage of the strip is read by two roller contact type electrolimit gages located one on each side of the mill between mill and reels.

21 AND 53 x 60-IN. FOUR-STAND TANDEM COLD MILL

Columbia-Geneva Steel Division
United States Steel Corp.
Pittsburg, Calif.

All stands of this mill (Figure 5) are driven directly through conventional pinion stands without gear drives

Figure 6 — Layout of 21 and 53 x 60-in. 4-stand tandem cold mill.



of any type and the tension reel is also driven directly from its motor. The motors for stands 1 and 2 have single armatures. The motors for stands 3 and 4 and the tension reel have two armatures each.

The total rated power in the main drives and tension reel is 10,300 hp. The reel block is 24-in. diameter and the maximum coil diameter is 60 in. The maximum coil weight is 30,000 lb. The maximum strip speed is 3160 fpm.

The mill stands are spaced on 13-ft 6-in. centers. See Figure 6. The mill is supplied from an entry coil ramp with four disappearing stops. The coils are fed to the mill from a coil box of the rotating side guard type. When feeding, the coil is supported on a pair of idle rollers mounted on the plunger of a hydraulic lift cylinder. Three other rollers in the coil box frame back up the coil on the side toward the mill. On the delivery end of the mill after the coil has been stripped from the reel block, it is rolled down a ramp, and weighed while rolling, the scale platform (about 13 ft 6 in. long) forming a part of the delivery ramp.

An interesting feature of this mill is the provision made for roll and strip cooling and lubrication. Provision was made for a dual or alternative system for the use of a recirculated cooling and lubricating solution or for the use of water for cooling with palm oil as a lubricant.

This dual system is virtually two separate systems having certain parts or elements in common. Circulating pumps, suction strainers, filters, and main piping headers are common to both systems. For the recirculated coolant system, two vertical cylindrical tanks equipped with agitators are provided, each of 7500-gal capacity. One of these tanks is used for coolant mixture preparation, while the other is in use on the mill. There are two 2500-gpm circulating pumps, one of which is intended as a standby unit.

For the use of water and palm oil, there is one rectangular 20,000-gal skimming tank 41 ft long × 10 ft wide arranged with a compartment at one end for receiving the palm oil and scum that separates from the water. The water is recirculated through a cooler and returned to the mill. The original reason for arranging for recirculation of the water was to conserve water as much as possible. Provision is made for adding make-up water intermittently as needed. The rise in level of the water in the tank when water is added, serves to aid in floating the accumulated palm oil and scum over a weir into the palm oil compartment.

The equipment for application of palm oil to the mill is along the lines previously described. Cellars for machinery lubrication equipment and for the coolant equipment just described are separate and are at opposite ends of the mill which is arranged along one side of the building, with motors and electrical equipment in the adjoining building.

21 AND 53 x 93-IN. THREE-STAND TANDEM COLD MILLS

Great Lakes Steel Corp.

Ecorse, Detroit, Mich.

In this installation (Figure 7) there are two 93-in. three-stand tandem mills and an older 54-in. three-stand tandem. One of the 93-in. mills was built in 1946. The other was completely modernized at about the same time. The first mentioned 93-in. mill has a top speed of approximately 1600 fpm. It is equipped with conventional pinion stands, driven directly by a 4000-hp motor for each stand, the total rated power including that of the tension reel motor being 12,800 hp. This mill has exceptionally heavy housings and is powered for reductions requiring high torque at the rolls.

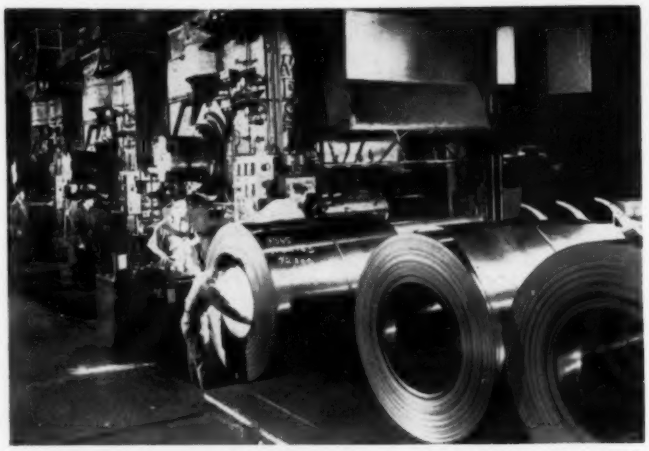


Figure 7 — Illustration shows 21 and 53 x 93-in., 3-stand, tandem cold mill at Great Lakes Steel.

The other 93-in. mill has a somewhat higher top speed (approximately 2200 fpm) and has the same rated horsepower, that is 4000 hp for each stand and 800 hp for the reel.

The drives are direct at motor speed through conventional pinion stands. The motors for stands No. 2 and No. 3 of this mill and for stand No. 3 of the first mentioned mill have two armatures. The other motors are single armature motors.

The entry and delivery equipment of both mills is designed to handle coils up to 72 in. in diameter and a maximum width of 90 in. with a maximum weight of 50,000 lb. The reel block is 28 in. in diameter with an 18-in. main bearing and a correspondingly heavy shaft capable of supporting the cantilever load of these wide heavy coils without an outboard bearing. The motors are geared to the reel drum shafts with ratios of 2.1 to 1 and 1.6 to 1 respectively, motor to reel.

21 AND 56 x 56-IN. FIVE-STAND TANDEM COLD MILL AND 21 AND 56 x 66-IN. FOUR-STAND TANDEM COLD MILL

Bethlehem Steel Co.

Sparrows Point, Md.

The 56-in. wide mill was built as a four-stand mill in 1946. At the time the 66-in. four-stand mill was built in 1951, the 56-in. mill was converted into a five-stand mill by the addition of another stand. The 56-in. mill after this conversion was better adapted to the rolling of tin plate and other light gages to supplement the capacity of two older and slower 42-in. five-stand mills.

The 56-in. mill now has a top speed of about 4100 fpm, and a total rated power of nearly 15,000 hp. The first two stands are driven at motor speed through conventional pinion stands (see Figure 8). The last three stands have individual motor drive to the work rolls through gear drives decreasing the speed from motor to rolls in stand No. 3 and increasing the speed in stands No. 4 and No. 5. The ratios of mill speeds to motor speeds are 1 to 1.1 for stand No. 3, and 1.1 to 1 in stands No. 4 and No. 5.

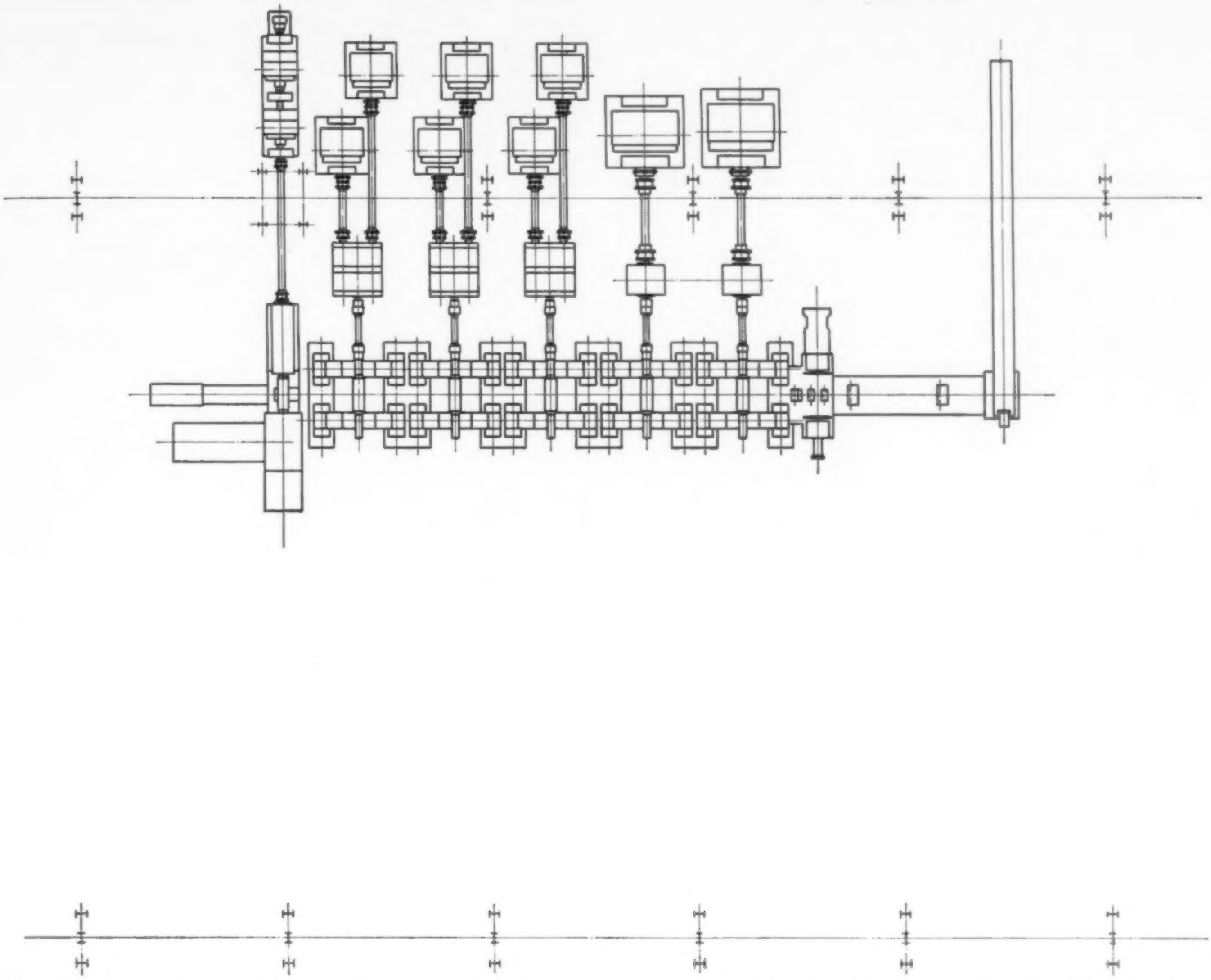


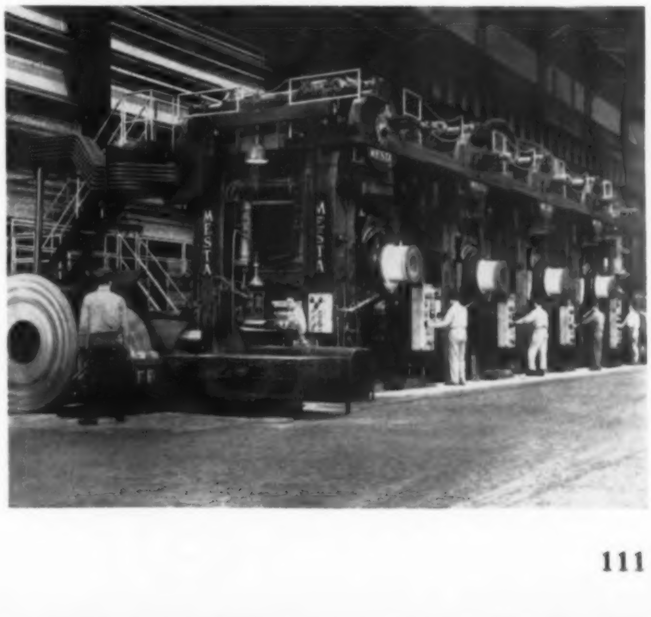
Figure 8 — Layout shows 21 and 56 x 56-in., 5-stand, tandem cold mill located at Bethlehem Steel's Sparrows Point plant.

All except the one for the tension reel are single armature motors. The gear drives for stands No. 3, 4 and 5 have staggered gear sets arranged in such a way that the motors driving top and bottom rolls are staggered vertically at the approximate elevations of their respective rolls. The motors are also staggered in the horizontal plane so that the driving spindle of the far motor just clears the frame of the motor nearest to the drive.

The 66-in. mill (Figure 9) is in the same building about 500 ft distant. Both mills are laid out along the axis of the building with motors in the adjoining building. This mill has conventional pinion stands for stands No. 1 and No. 2, and individual roll drives for stands No. 3 and No. 4. These are quite similar to the ones employed in the 56-in. mill, the ratios also being approximately the same. The speed is decreased from motor to roll for stand No. 3 and increased for stand No. 4. The top speed of this mill is approximately 3000 fpm, and the total rated power is 17,500 hp. The motors for stand No. 2 and the tension reel have two armatures. The other motors have single armatures.

The 56-in. mill is served by a gravity entry conveyor which transfers pickled coils from the adjacent building. The 66-in. mill (see Figure 10) has a complete system of power driven chain conveyors running at right angles to the axis of the mill. These conveyors bring pickled coils to the mill from the adjacent building on one side of the mill, and transfer coils from the delivery end

Figure 9 — The 21 and 56 x 66-in., 4-stand, tandem cold mill is located in the same building at Sparrows Point as the 56-in. mill.



of the mill to the adjacent building on the other side of the mill.

The delivery conveyor is equipped with a scale near the tension reel. It delivers coils on their horizontal axes to a point in the next building where they can be kicked off to a ramp serving nearby shearing equipment, or upended and delivered to another chain conveyor from which they are lifted for annealing.

Maximum coil diameters are 70 in. for the 56-in. mill and 72 in. for the 66-in. mill. The respective maximum weights are 50,000 lb and 60,000 lb. The reel blocks are 20½ in. in diameter for both mills. Stand spacing is 14 ft for the 56-in. mill; 15 ft for the 66-in. mill.

21 AND 53 x 48-IN. FIVE-STAND TANDEM TIN MLIL AND 21 AND 53 x 80-IN. THREE-STAND TANDEM COLD MILL FOR SHEET GAGES

Societe Lorraine deLaminage Continu "Sollac"

Ebange, Moselle, France

These mills are located in the same building and are arranged parallel with the axis of the building and almost in line with each other. See Figure 11. The tin mill has been in operation for about 15 months. The three-stand sheet mill is not yet in operation as of February 1954.

The center stands of the two tandem mills are about

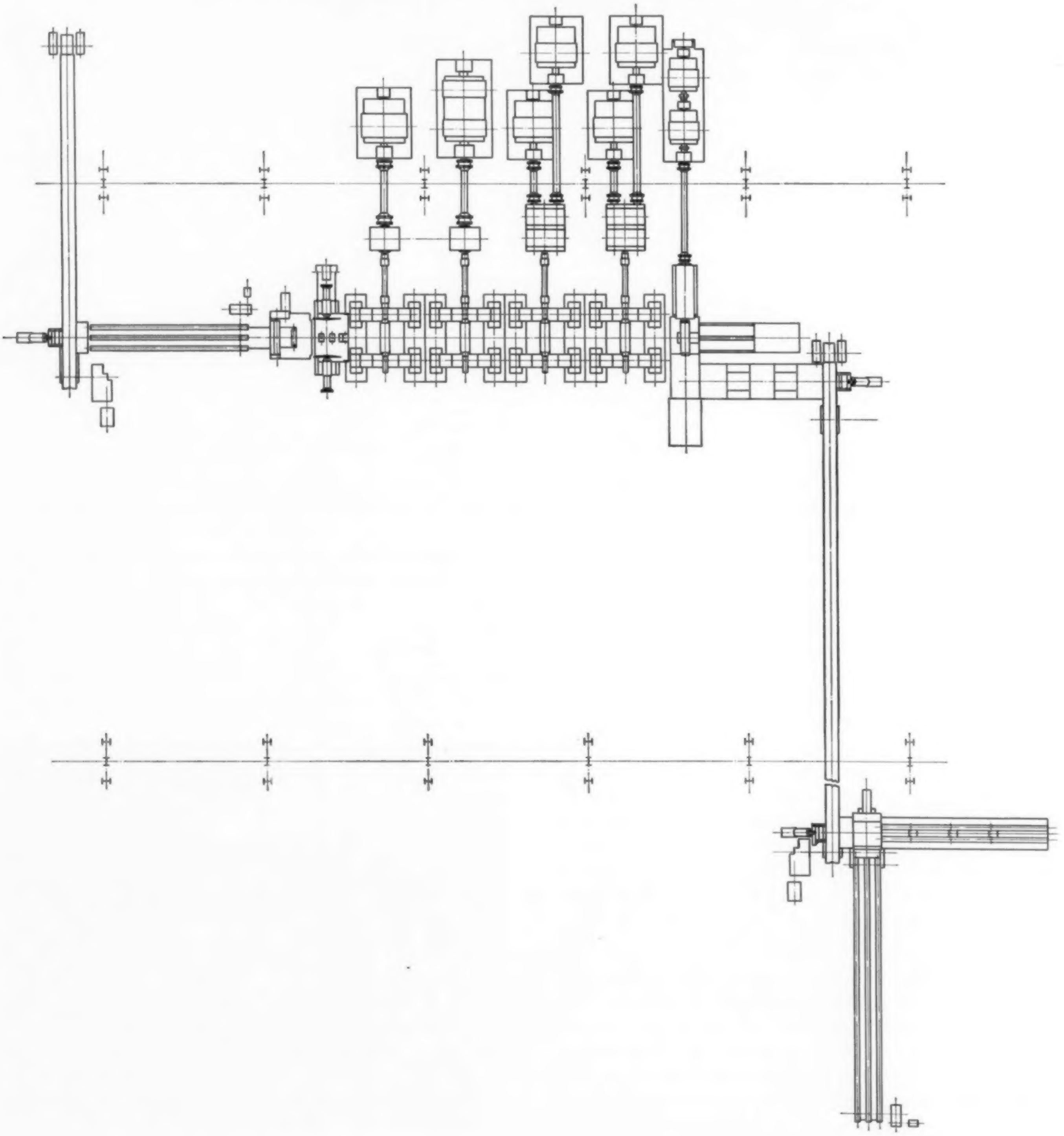


Figure 10 — Total rated horsepower of Bethlehem Steel Co.'s 66-in. mill is 17,500.

250 ft apart and the mills feed in opposite directions. The motors and motor-generator sets for both mills are placed in an adjoining building.

The tin mill has a total rated power for main drives and tension reel of 15,800 hp. The maximum speed is 5060 fpm. The sheet mill has a total rated power of 9800 hp and the maximum speed is 1925 fpm. All of the stands of both mills are driven directly at motor speed through conventional pinion stands from motors, all of which have multiple armatures except the motors for No. 1 stand of both mills. The maximum coil diameter for the tin mill is 66 in. and the maximum weight is 36,000 lb. The diameter of the collapsible block is 16½ in. The maximum coil diameter for the sheet mill is 66 in. and the maximum coil weight 55,000 lb. The reel block is 24 in. diameter.

The auxiliary equipment is located in cellars at either end of each mill, and there is practically a continuous cellar between the mills. The lubricating equipment for the mill machinery is located in the cellars on the delivery ends of both mills, that is on the outer ends of the overall layout.

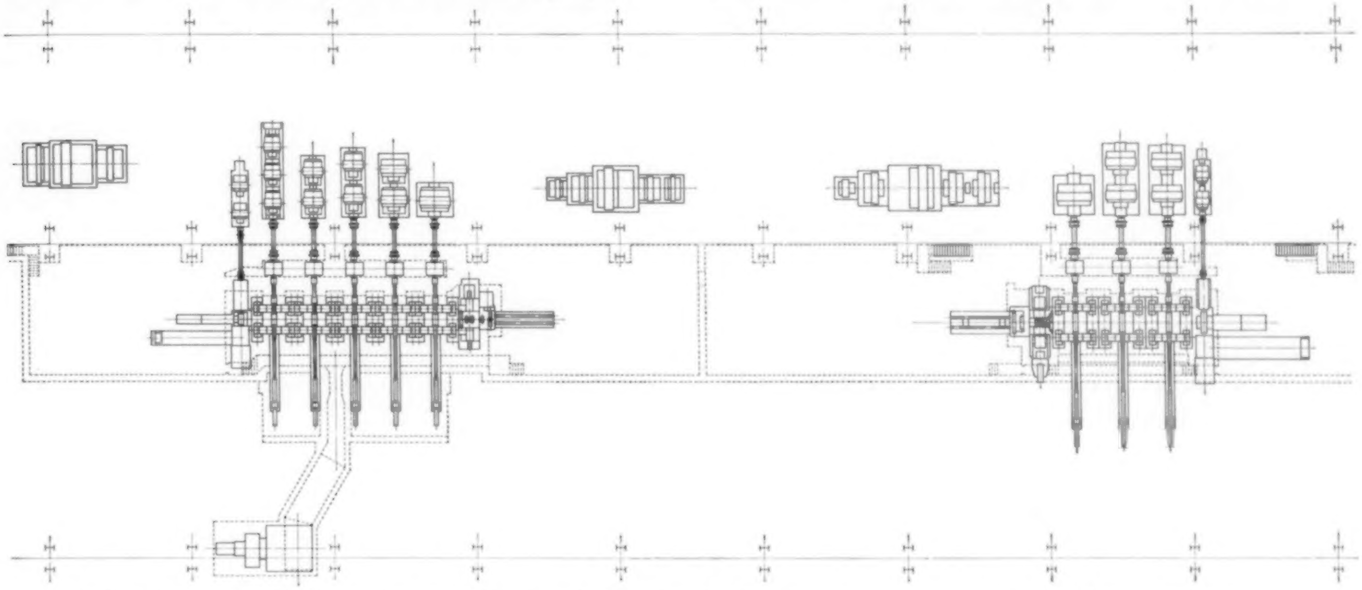


Figure 11 — These mills mark the entrance of France into high speed continuous sheet and tin production.

The equipment for cooling and lubrication of rolls and strip is located at the entry end of each mill, and the cellars are adjacent end-to-end and are connected so that they form practically one cellar although all of the equipment for the two mills is distinct and separate.

The tin mill has a recirculating water system with a large skimming tank for roll and strip cooling and palm oil is used for lubrication. Two considerations made it necessary to recirculate the water; the necessity to conserve water and the fact that the water effluent from the skimming tank could not be discharged into nearby water courses. It is possible to do a fairly good skimming job in the skimming tank, but a little oil would inevitably escape with the water. Where this is discharged into a river or stream of some size, only a slight oil slick is visible, but in this case not even this slight pollution was permissible.

The scheme has worked quite well. Water is added intermittently for make up and the rise in level in the tank is used to float off the palm oil scum. Maintenance of filters and coolers has not been too troublesome. In practice the water in the system is disposed of periodically (about once a month when accumulation of dirt and sludge and generally increasing contamination make it advisable).

21 AND 53 x 48-IN. FIVE-STAND TANDEM TIN MILL
AND
21 AND 56 x 80-IN. FOUR-STAND TANDEM COLD MILL FOR SHEET GAGES

Fairless Works
United States Steel Corp.
Fairless Hills, Pa.

These mills are the latest of our domestic mills. The tin mill (Figure 12) has a top speed of approximately 7000 fpm and a total rated power of over 21,000 hp. The first two stands are driven directly from the motors through conventional pinion stands. The last three have speed increaser drives with ratios of 1.5 to 1, 1.5 to 1, and 2 to 1. On these stands each work roll is driven separately from its motor with no mechanical connection between the rolls.

The first stand has a single armature motor. The second stand has a double armature motor. The third stand has two separate motors of one armature each with a separate motor for each work roll. The fourth stand has two motors with two armatures each arranged in the same way, and the fifth stand has three armatures for each of two motors, six armatures in all for this stand. The tension reel has a two armature motor.

The stands are spaced on 13-ft 8-in. centers. The equipment is designed for a maximum coil diameter of 72 in. and a maximum weight of 36,000 lb. The collapsible reel block is 16½ in. in diameter, of three-segment design.

The sheet mill (Figure 13) has a top speed of 3100 fpm. The total rated horsepower is over 21,000. All of the stands are driven directly from their respective motors and all have conventional pinion stands. The first stand has a single armature motor, the second stand a two armature motor and the third and fourth stands motors with three armatures each. The tension reel motor has two armatures.

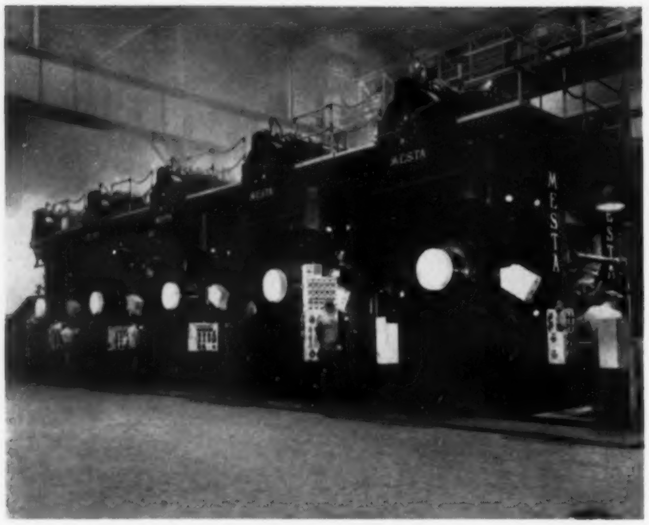


Figure 12 — This 5-stand, 21 and 53 x 48-in., tandem cold mill has a top speed of about 7000 fpm.

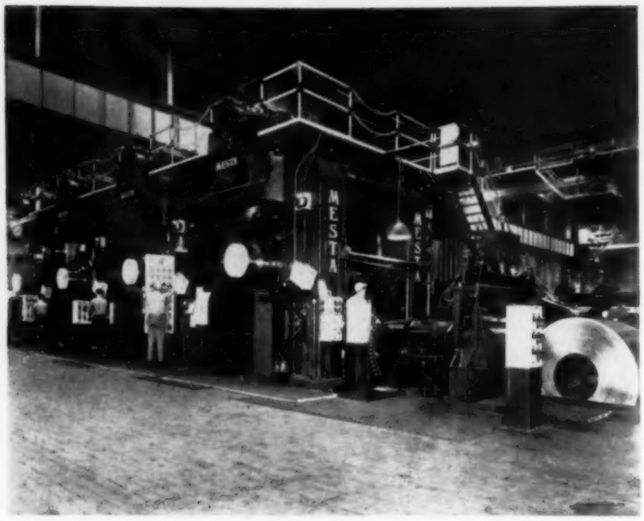


Figure 13 — This 21 and 56 x 80-in., 4-stand tandem cold sheet mill has a top speed of 3100 fpm.

The two mills (see Figure 14) are parallel to each other and both mills feed across the building. With this transverse arrangement there are no separate enclosures for main motors or motor-generator sets. These electrical units are out in the open in the mill building.

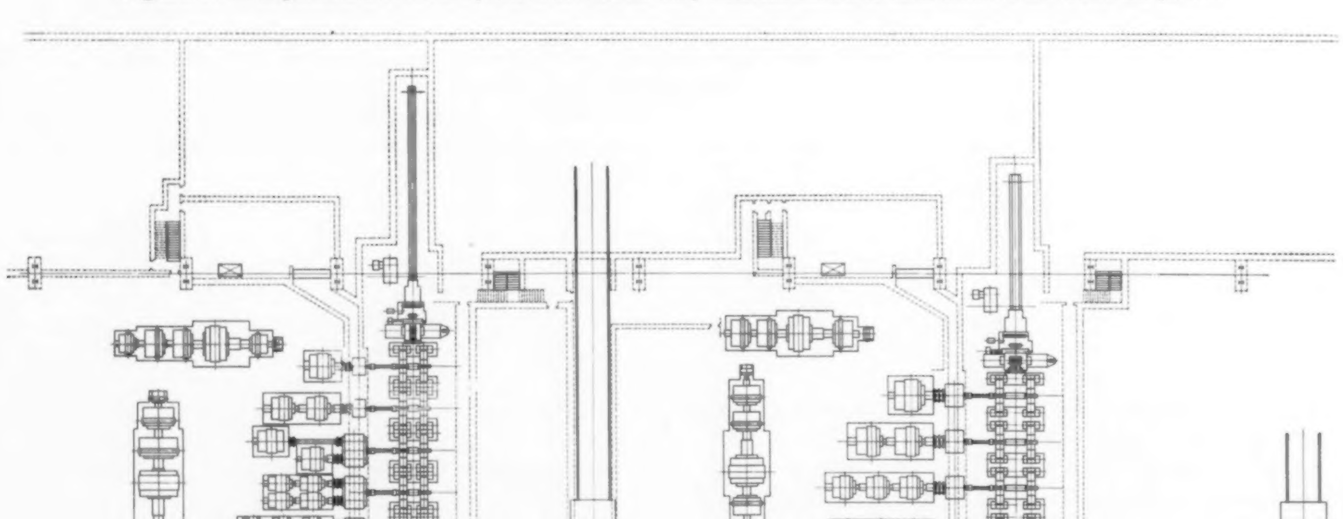
Both mills are served at both entry and delivery ends by a system of conveyors which facilitates the handling of the coils to and from the mills, and at the same time effects the transfer of coils between buildings.

The entry equipment of both mills is similar in general design. The coil is received from the entry conveyor and is lowered to a pair of positioning rollers, by a hydraulic device that serves at the same time (when in its elevated position) as a coil stop to prevent the premature discharge of a coil from the conveyor. The coil boxes of both mills have feeding pinch rolls and are of the same design as that described earlier in this paper.

Since both mills are equipped with recirculating coolant solution systems, provision was made for exhausting the vapor or fog from both ends of both mills. The air and vapor is drawn down between stands into tunnels leading to the fans, and then to vertical discharge ducts rising through the mill building between crane runways to stacks through the roof. Each mill is served by two fans of 80,000-cfm capacity each. The vertical rising ducts are located where there will be the least obstruction of the working floor areas of the mill building.

The arrangement of basement areas for the auxiliary equipment is notable. A space, 69 ft wide and eight

Figure 14 — Layout shows 48-in., 5-stand and 80-in., 4-stand tandem cold mill at the Fairless plant.



bays (384 ft) long, was reserved for this purpose to serve both mills. About seven of the eight bays are fully occupied by equipment which is arranged as conveniently as possible to the mill stands. Machinery lubrication units are grouped together for each mill, as is the equipment for roll and strip cooling and lubrication. All roll balance and auxiliary hydraulic power equipment for both mills are grouped together in the central area between the two mills. The fog exhaust fans at the entry ends of the mills also occupy a portion of this basement space.

Both mills have dual systems for roll and strip lubrication and cooling. The five-stand tin mill has a complete circulating system for coolant solution and in addition a 20,000-gal skimming tank for water and palm oil with provision for recirculating the water. There is also a complete circulating and feeding system for palm oil.

The four-stand sheet mill has a circulating coolant solution system with separate provision for throwing clean water on the fourth stand only to clean the strip. This water does not flow back into the circulating system but is discharged into a separate tank equipped with evacuating pumps. The entire basement is ventilated by four exhaust fans of 59,500-cfm capacity each.

16 AND 53 x 56-IN. FOUR-STAND TANDEM COLD MILL

Allegheny Ludlum Steel Corp.

Brackenridge, Pa.

This mill as of February 1954 is in process of construction. See Figure 15. It is intended to roll alloy steels, that is, high silicon and stainless alloys. It will supplement the corporation's cold rolling facilities at Leechburg where there is a 28-in. wide four-stand mill, installed about seven years ago. The new Brackenridge mill will be a complement to the 56-in. hot strip mill recently installed at the same plant. The top speed of the mill will be about 2150 fpm, the total rated power 7500 hp. All of the motors will have two armatures.

The mill will have both coil box and feed reel at the entry end and will be served by a system of conveyors having two runs at right angles, one in line with and next to the mill, and one serving as a transfer between buildings. The delivery end will also be equipped with a short conveyor in addition to the usual tension reel, elevating stripper and belt wrapper.

The mills just described are typical of modern mills for cold reducing. Not only have new mills been built, but extensive modernization programs have been undertaken whereby existing mills have been speeded up (with corresponding increase in power) and otherwise brought up to date. Such programs have usually included the substitution of new coil handling equipment for old, involving such items as coil boxes, feed reels and other entry equipment, tension reels, belt wrappers, conveyors, etc., for handling heavier coils. Typical of these with respect to alterations made to existing tandem mills are the following:

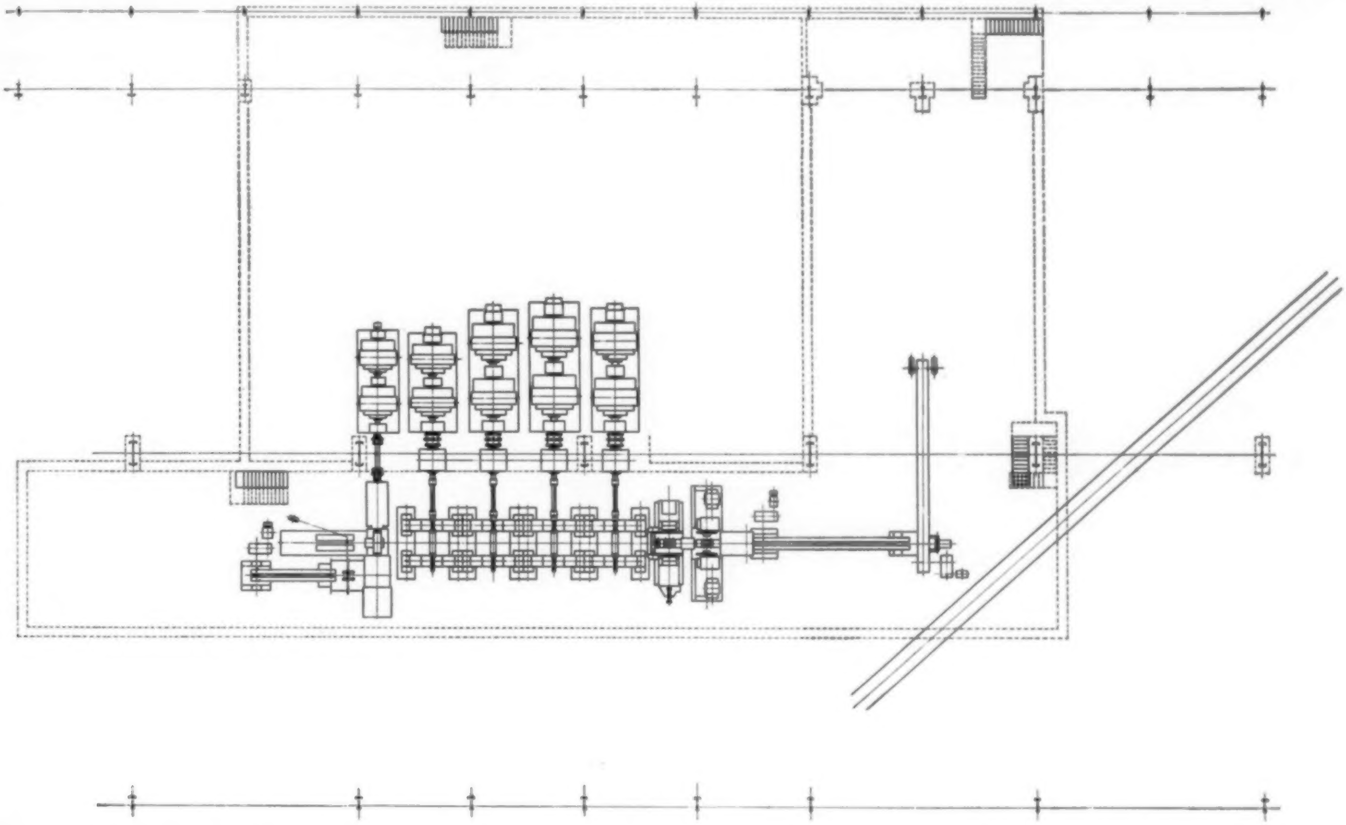


Figure 15 — This 16 and 53 x 56-in., 4-stand, tandem cold mill was designed for rolling alloy steels at Allegheny Ludlum Steel Corp.'s Brackenridge plant.

INLAND STEEL CO.

Indiana Harbor, Ind.

The speed of a 42-in. five-stand tandem tin mill was increased to approximately 4400 fpm with a total rated horsepower of over 14,000. To accommodate coils of a maximum diameter of 72 in. and a maximum weight of about 42,000 lb, entirely new entry equipment was supplied consisting of entry conveyor, down tilter, feed reel and auxiliary coil box, and new delivery equipment

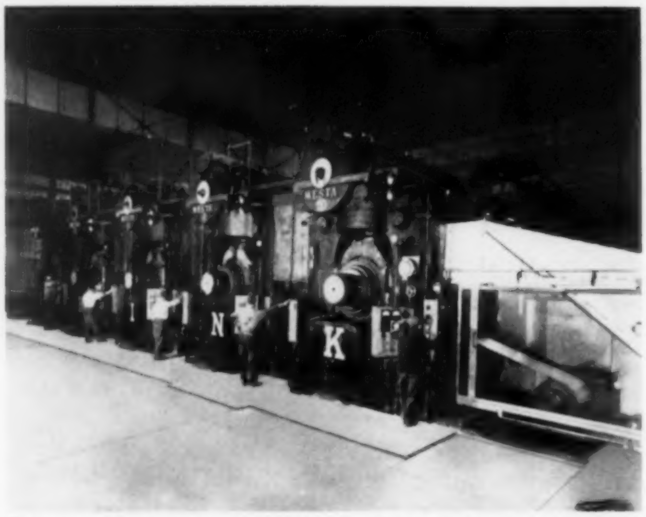


Figure 16 — Speed of this 42-in., 5-stand tandem tin mill was increased to 4400 fpm.

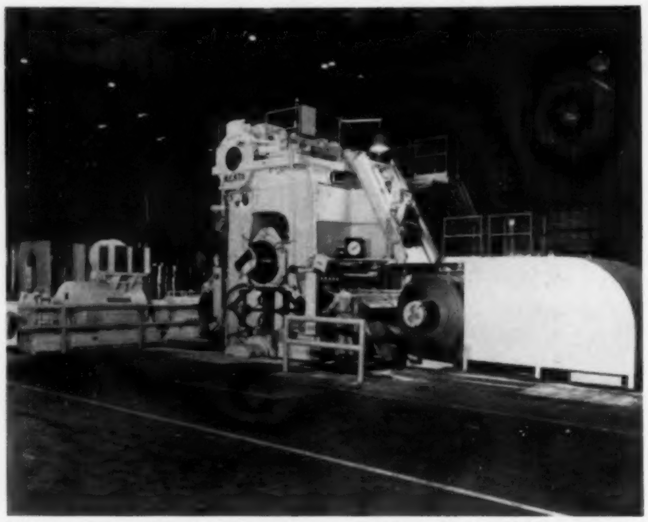


Figure 17 — Illustration shows a 20 and 53 x 80-in. single stand skin pass mill.

consisting of tension reel, elevating stripper and belt wrapper. See Figure 16.

UNITED STATES STEEL CORP.

Gary, Ind.

Two 42-in. five-stand tandem tin mills were increased in speed to approximately 4700 fpm with a total rated horsepower of approximately 14,000. New coil equipment for coils up to 65 in. in diameter and 35,000-lb weight consisted of entry conveyors, feed reels, tension reels and belt wrappers.

SKIN PASS OR TEMPER ROLLING

Equipment for skin pass or temper rolling has followed the same trend toward higher speeds and heavier coils. This operation on annealed stock for flatness or temper is always accomplished by dry rolling without lubrication of rolls or strip and without liquid cooling.

For tin plate gages the trend has been toward two-stand tandem mills with tension rolls front and rear. Tension between stands and both back tension and forward tension from the tension rolls constitute the main reliance for producing the desired elongation which is a criterion of the cold work done and the increase in temper accomplished.

For sheet gages, single stands are still used. The tendency is to combine with the mill the auxiliary equipment required to oil the strip and stamp it with the desired trade name or other identification. See Figure 17. One skin pass mill at the Ecorse, Mich. plant of Great Lakes Steel Corp. is combined with a flying shear and piler for skin passing, shearing and piling sheets in one continuous operation.

For measuring the elongation of the strip in the mill, an extensometer or elongation meter is sometimes applied to the mill. One principle that is used is to drive two otherwise idle rolls from the strip, one roll being located ahead of the mill and one behind. The differential in speed between the two rolls is measured by a combination of small transmitting selsyns, one driven from each roll, with receiving selsyn and a differential ratio meter reading directly in percentage elongation.

In an attempt to summarize and evaluate recent progress in cold rolling flat products, it is probably fair to say that there have been no extremely radical developments, but many improvements or refinements have been introduced. In spite of the spectacular increase in speed and power which has affected motors, main drives, spindle couplings and some other mechanical parts, it has not been necessary to make fundamental changes to the principal elements of the mill proper.

The increase in coil weight and size however has brought considerable change to coil handling equipment both in the mill and throughout the plant. Auxiliary services for hydraulic power, coolant handling, etc., have assumed a place of greater importance. Satisfactory cooling and lubrication of rolls and strip continue to challenge designer and operator.

Sustained production rates on tin plate gages over periods as long as a month now run on the best of these mills from 70 to 85 tons per hour. Rolling speeds of 4500 to 5000 fpm are in present use and perhaps will soon be common place on the highest speed mills. A record has been set for a day at an average hourly rate of a little over 100 tons. The record for a single hour has gone to 150 tons. The theoretical rolling rate for 36-in. wide, 32-gage tin plate (thickness 0.010 in.) at 5000 fpm is over three tons per minute or 180 tons per hour.

Thus far no serious or limiting mechanical weaknesses have been uncovered. It would require a rather thorough and intensive study of production rates and costs to determine accurately the value of the higher speed ceilings. There is of course the "law of diminishing returns." The strictly proportionate value of the increase can never be fully realized.

Sustained rolling rates over a long period produce more steel than does an occasional burst of speed. A fast mill rolls no more steel during a roll change than one forty per cent slower. The tortoise and the hare still run their proverbial and perennial race. Wrecks on the mill due to poor welds or unsatisfactory steel are costly at five or six thousand fpm. For once, however, in the history of the rolling mill business the operating people seem to have enough speed and power. Whether that will be the case on these mills ten years from now is anybody's guess.

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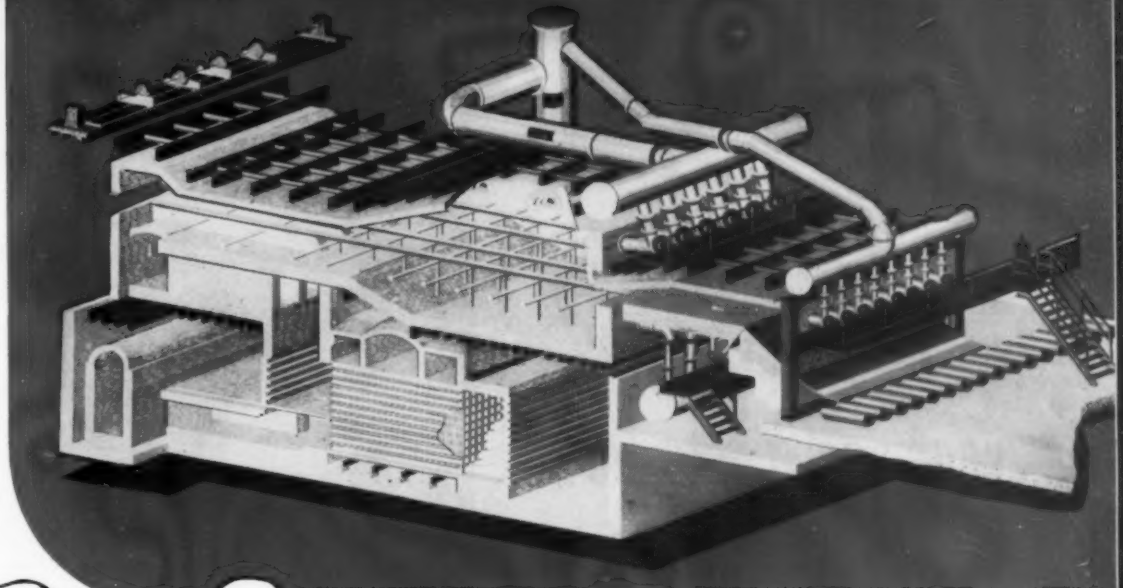

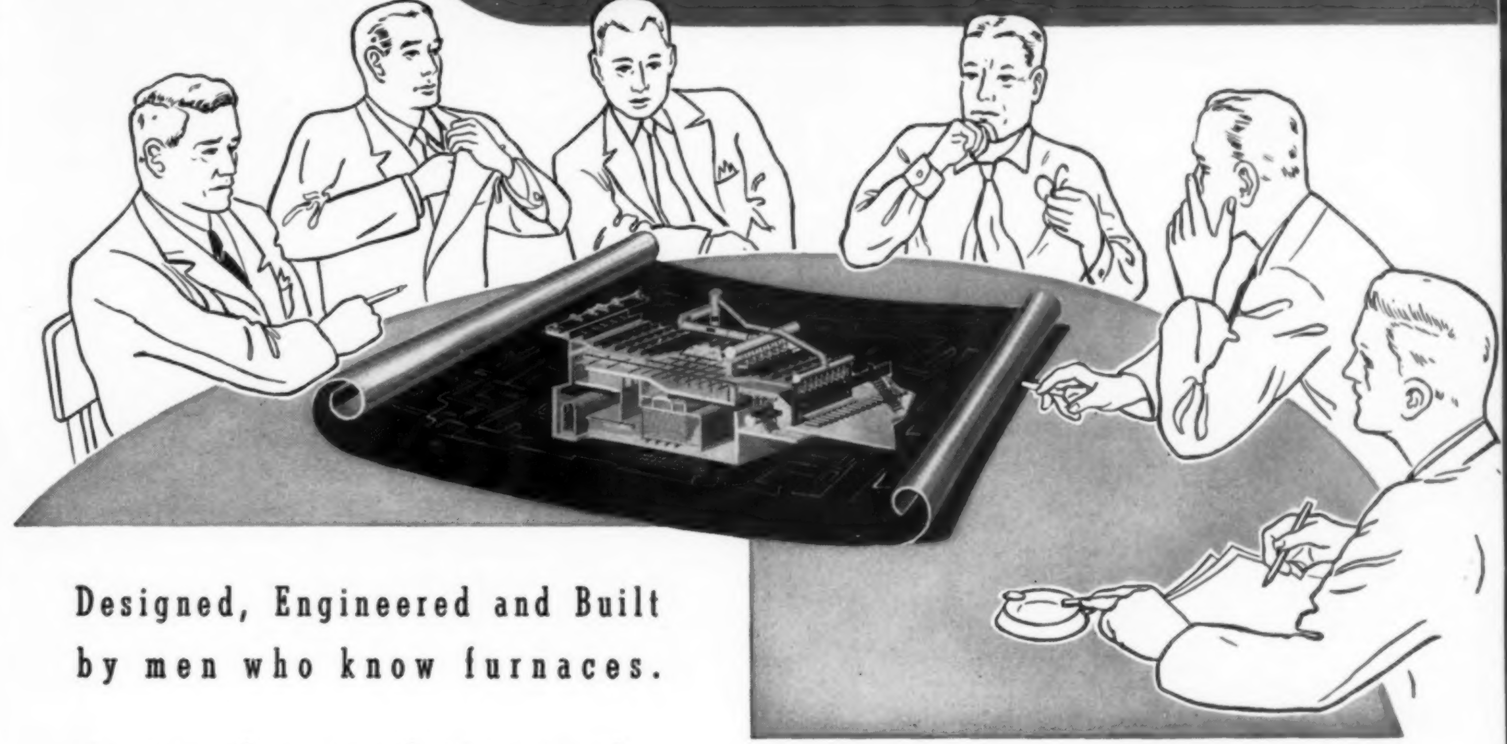

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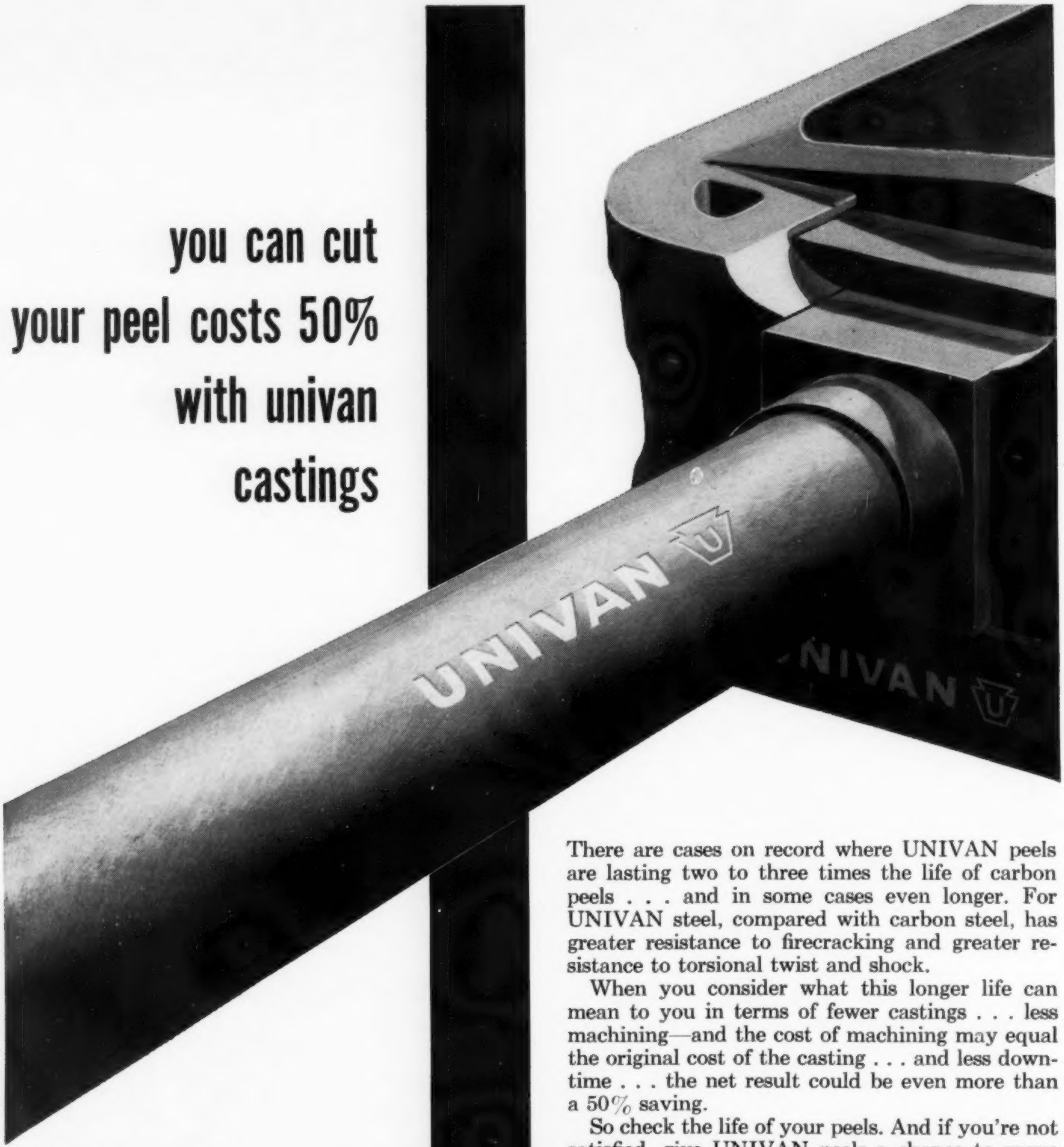

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Power From Atomic Energy

By CHARLES H. WEAVER
Manager
Westinghouse Atomic Power Division
Pittsburgh, Pa.

. . . . paper presented before Atomic Industrial Forum, Washington, D. C., May 24, 1954 . . . .

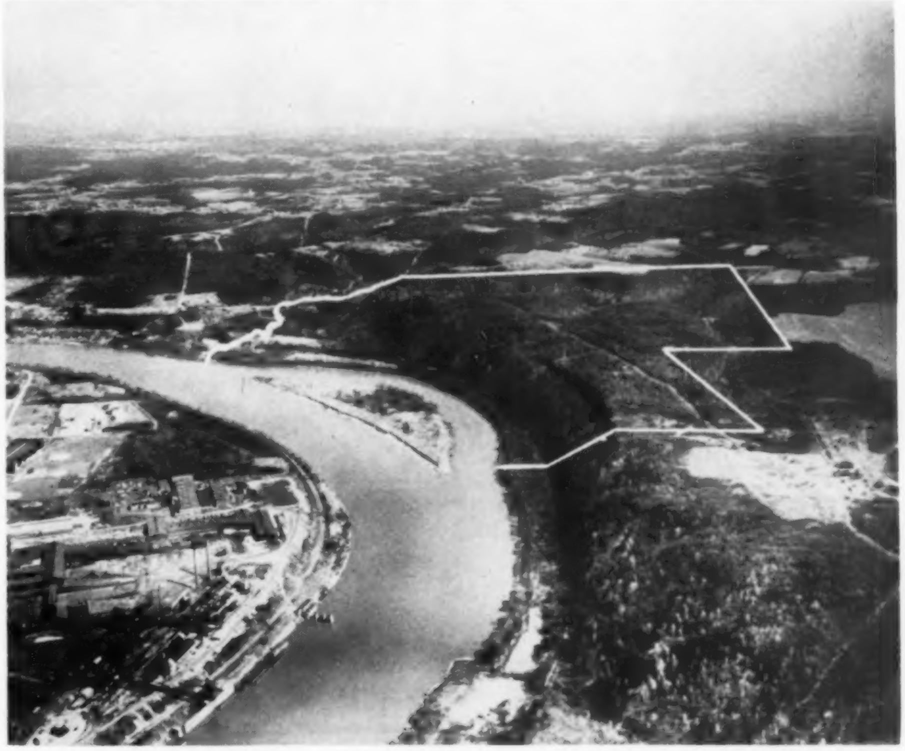
▲ EFFECTIVE July 1, 1953, our company was assigned responsibility for the development and design of a pressurized light water reactor and primary coolant circuit intended as the heat source for generating civilian electric power. To carry out this responsibility, we were authorized to do, or cause to be done, the following: (a) Such research and development work as is necessary for the design of the reactor and primary coolant circuit; and (b) the necessary design and engineering work, including scheduling of the work and preparation of plans and specifications. We were also assigned responsibility for the manufacture, fabrication, assembly, and testing of the pressurized water reactor.

It was expressly agreed that, at some later date, the commission would select a contractor or contractors for the engineering and construction of the steam plant, the electrical generating plant, and site facilities; for the procurement and installation of associated components; and for operation of the entire plant complex, including the reactor.

On October 22, 1953, Commissioner Thomas E. Murray formally announced the award of this contract to our company. In the course of his announcement, he invited industry to propose ways and means whereby it might participate in the project and help defray the cost.

On December 7, 1953 an official statement from Washington detailed the type of proposition which the commission hoped it would receive from industry. February 15, 1954 was set as the deadline for submitting proposals. On March 14, following the receipt and analysis of nine proposals, the commission announced that an offer made by the Duquesne Light Co. was most favorable to the Government and would be accepted. The offer stipulated that Duquesne would furnish a site for the entire PWR project, that Duquesne would build an electric generating plant, that it

Figure 1 — The new atomic power plant will be located on the south bank of the Ohio river near Shippingport, Pa.



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STRAIGHT **BARREL** **TAPER**

would contribute $5,000,000 toward the cost of the reactor plant, and that it would operate the over-all plant at no cost to the Government. In addition, Duquesne will purchase steam produced by the reactor plant at certain specified rates which vary from 48.3¢/million Btu the first year to 60.3¢/million Btu the fifth year.

On April 12, 1954, the commission announced that this first large-scale atomic power plant will be built near the village of Shippingport, Pa., on the south bank of the Ohio River about 25 airline miles from Pittsburgh. Figure 1 shows an aerial view of the site.

When work on the primary plant was started, we were given the following general specifications:

1. Generation of at least 60,000 kw of useful electric energy.
2. Use of light water cooled and moderated, slightly enriched uranium-type reactor.
3. 600 psi saturated or higher steam conditions.
4. Fuel element life as long as possible between chemical reprocessing.
5. Refueling with minimum shutdown period.
6. Simplified reactor control system.
7. Central station type turbine and electric generating equipment.
8. Conventional central station steam, electric, and other auxiliary systems.
9. Commercial standards of equipment.
10. Use of concrete for shielding.
11. Minimum possible construction cost of the plant.
12. Minimum possible operating cost of the plant consistent with the above requirements.

As we analyzed our task, we saw that our severest problem centered upon development and design of the nuclear core. The two major aspects of this problem involved, first, development of suitable materials for the reactor and, second, development of basic physics design data and relationships capable of being used to calculate the nuclear design of the reactor core. As of mid-1953 we knew of no fuel material having corrosion-resistance characteristics and radiation stability which showed promise of meeting the conditions laid down in the specifications. Moreover, the general theory and the calculation techniques available at the time were clearly insufficient to serve as a foundation for accurate design of the nuclear core.

We therefore undertook a vigorous development program to attack these key materials and physics problems. On the materials side, we gave priority to the production, test, and study of many potential fuel materials. A considerable effort went into the development of suitable structural materials, and the fabrication of fuel into various shapes. An extensive in-pile test program was formulated for testing both sample materials and sample fuel elements. This work involved the design, fabrication, and installation of several high temperature, high pressure test loops for use in the Chalk River and MTR reactors.

The physics program primarily consisted of constructing critical assemblies, plus the analytical work required to analyze test results and translate these into a practical and economically attractive nuclear design.

The bulk of the effort on reactor design was aimed at developing information necessary to choose a fuel element shape and to establish the thermal design of the reactor. This program involved preparing a number of different core designs associated with various fuel element types. It involved heat transfer studies to develop the basic data required to prove the design; and here we made use of a special fuel element burnout test loop. We also conducted a survey and study of various reactor control techniques.

In addition, we started preliminary design of the primary coolant system, looking toward determination of the number and size of primary loops, the methods to be used in constructing components, and preparation of specifications for long delivery items. We also began work on site design, plant layout, the plant electrical systems, and plant control.

The basic design of the PWR plant is now and for some time has been an established reality, in keeping with the general specifications which the commission laid down.

The main coolant system, which serves both to absorb heat generated by the reactor and to deliver heat to the steam generators, will consist of four loops operating off the reactor vessel, as shown on Figure 2. Each loop, in turn, consists generally of a pump, a steam generator, shutoff valves, and interconnecting pipe. The pumps continuously circulate coolant water between the reactor and the steam generator. The steam generator, for its part, is the connecting link between the primary system and the steam system. It consists of a water-to-water heat exchanger, and a steam drum and separator. The shutoff valves permit us to isolate one loop if it is not required, or to repair one loop while the other three loops are operating.

The water in the primary plant will circulate at a pressure of some 2000 psi to prevent boiling in the core and to eliminate cavitation problems. The average temperature of the primary plant water is maintained at about 525 F.

The primary coolant loops are so designed that the rated plant output is produced with three of the four loops operating. The fourth loop can be operated if desired, but will normally serve as a spare. The loops divide the load equally, and the steam generated by each is fed to a steam header and delivered to the turbine. To produce 60,000 kw net with 3 loops operating, the pump in each loop circulates water at a rate of about 16,000 gpm. This makes a total of about 48,000 gpm through the reactor. About 1000 hydraulic horsepower is required to circulate the water in each of the three loops. All surfaces of the primary plant which come in contact with high temperature primary coolant water probably will be made of stainless steel. All components will also be designed to prevent leakage of the primary coolant water from the primary system.

In addition to the main coolant system, the primary plant involves a number of auxiliary systems. These accomplish such necessary functions as maintaining the primary system pressure at 2000 psi, filling and draining the primary system, purifying the water, providing for control of the reactor, dissipating the decay heat of the reactor after shutdown, etc. Preliminary designs of many of these systems have been prepared.

The primary water is maintained at 2000 psi by a pressurizing tank which floats on the system and is connected to one of the reactor outlet pipes. This tank is normally filled with about equal volumes of water and saturated steam at more than 600 F. The head of steam is maintained by electrical heaters in the water. Load changes are accompanied by some volume change of the primary water. The head of steam expands or contracts to accommodate this water volume change.

The most interesting and highly developmental part of the plant is, of course, the reactor core. It will consist of a geometrical pattern of closely spaced fuel elements. The heat generating material will be slightly enriched uranium, that is, uranium containing a slightly higher amount of the 235 isotope than natural uranium as mined from the earth. More than 10 tons of uranium will be used in the first core. The fuel elements will be protected by a corrosion-resistant material designed to prevent the coolant water from becoming contaminated with particles of uranium and fission products.

These fuel elements will be formed into a right circular cylinder about 6 ft in diameter and 7.5 ft high. The maximum fuel element surface temperature will be less than 636 F, the boiling point of water at 2000 psi. The maximum heat flux will be over 350,000 Btu per sq ft per hr, and the average power density will be about 45 kw of heat per liter.

The reactor container, as well as the entire plant, is being so designed that fuel elements of various shapes and materials of various types can be used in cores following after the first core. Such flexibility will add somewhat to PWR costs, but we think that this feature is appropriate to a developmental plant and that it may help importantly in advancing atomic power technology.

The reactor vessel, which contains the core, will be built large enough to accommodate cores physically bigger than the first one. Here is another aspect of the flexibility feature just mentioned. The vessel shell will be about 9 ft inside diameter and have an over-all height of over 25 ft. This shell will consist of carbon steel clad with stainless steel. The cylindrical wall of the vessel will be penetrated by the four inlet and four pipe outlet connections for the four main coolant loops. A contract for the design and manufacture of this vessel is being negotiated.

The steam generators will consist of two major components: First, the heat exchanger portion and second, the steam drum. The heat exchanger will consist of a bundle of stainless steel tubes, the ends of which are welded into heavy tube sheets. The entire assembly will be enclosed in a steel shell. Primary coolant will flow through the inside of the tubes. The steam plant feed water will be fed into the shell side of the heat exchanger and will be converted to steam as it flows upward over the outer surface of the tubes. The steam thus generated will rise to the steam drum where it will be dried by passing through a conventional steam separator. The steam will leave the steam drum at 600 psia saturated. We have placed firm price orders for the four steam generators. The Foster Wheeler Corp. will build two and the Babcock and Wilcox Co. will build two. It is felt that the relatively small additional cost of splitting this order is more than justified on the basis of additional knowledge to be gained, since the two companies are using designs which differ significantly.

The pumps will be single-stage centrifugal units driven by induction motors of the canned type. Use of canned motors permits elimination of the maintenance and leakage problems likely to be encountered if rotating seals were employed. The Westinghouse atomic equipment department is now designing a prototype pump and motor which will be built and tested before manufacture of the final units. The PWR pumps will involve an output of about 1000 hydraulic horsepower, and an input of about 1200 kw.

The primary coolant stop valves will be of the gate type. At least some of these valves will be designed to permit remote operation. They will be hermetically sealed and will function hydraulically. A prototype main coolant valve is now on order from the Crane Co.

The primary coolant system pipe will be approximately 18 in. in outside diameter. It will be fabricated from stainless steel. It seems probable that the pipe and necessary elbows will be manufactured by rolling and welding stainless steel plate.

Regarding the nuclear control of this plant, we intend taking advantage of the inherent stability of pressurized water reactors as the basis for control during power changes. Due to the negative temperature coefficient

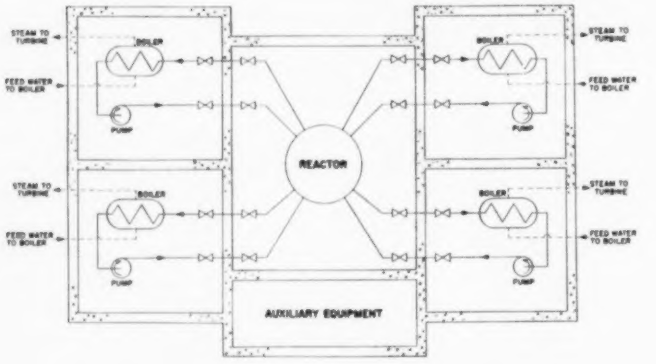

Figure 2 — Four loops operate off the reactor.

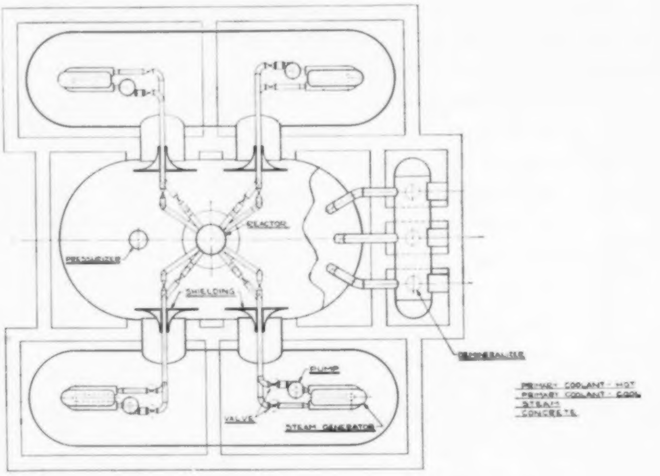

Figure 3 — With normal operations it is planned to operate three loops at a time.

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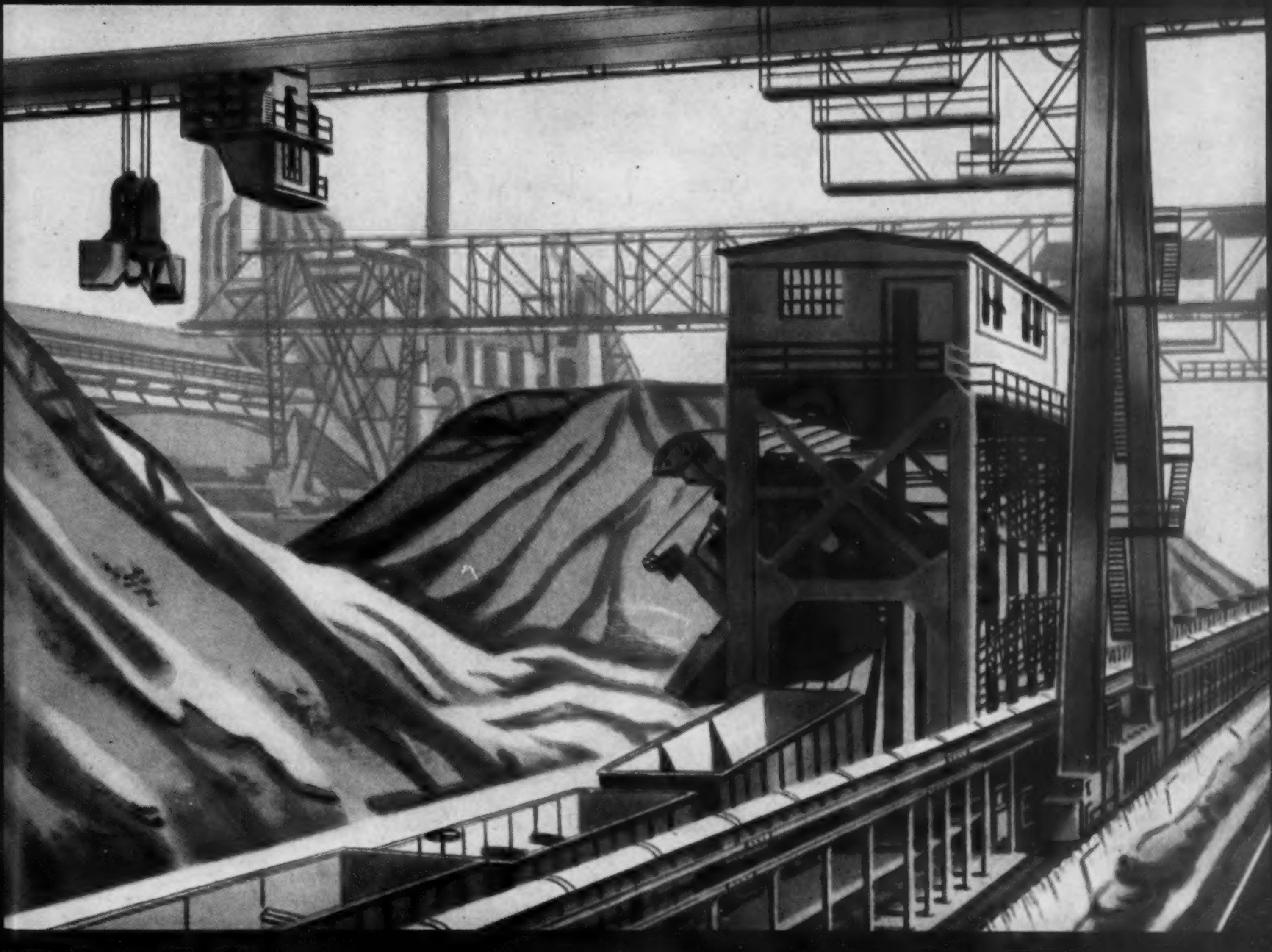

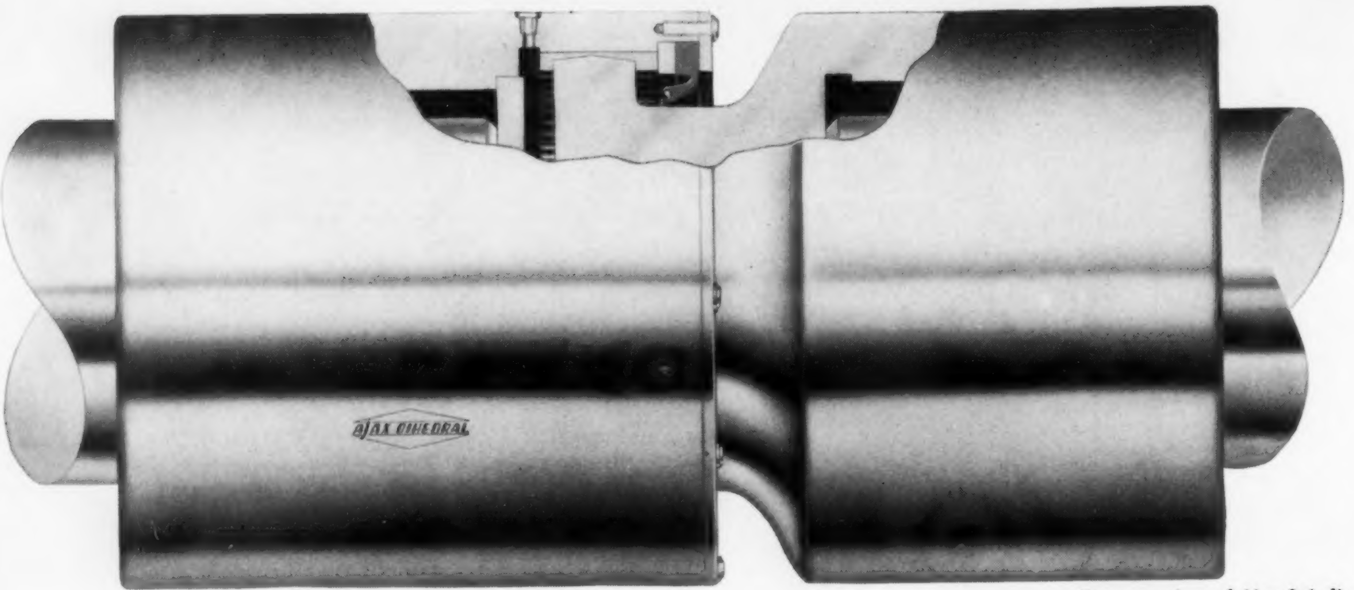

Cut-away view of Ajax Spindle Shaft Dihedral Coupling as used between pinion stands and rolls.

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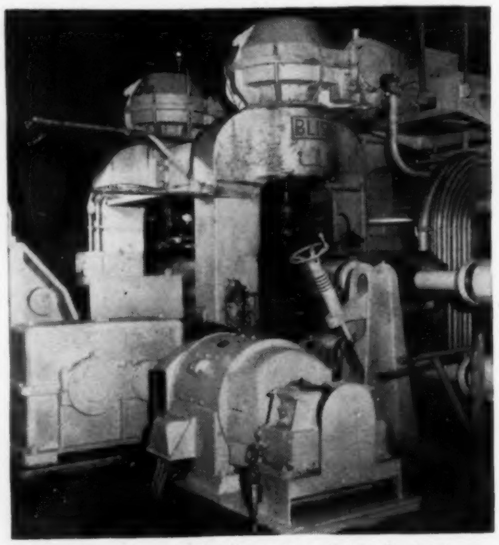

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which can be designed into such a reactor, the core will automatically maintain the temperature of water flowing through it at a constant value. Thus, if heat is removed from the primary coolant and if the coolant water temperature therefore decreases, the reactor automatically restores this heat by increasing its power output until the water temperature regains the original value. The reverse is true when the rate at which heat is being removed from the primary water is decreased. The reactor itself accomplishes this control automatically without the operation of any equipment.

The entire primary plant will be enclosed in a steel container to retain any radioactive materials which might escape from the plant as a result of an accident. Although such accidents are extremely improbable, safety requirements are such that, at least on this first plant, great precautions must be taken.

Figure 3 shows a plan view of a proposed layout for the primary plant showing the concrete shielding, the container housing, the primary plant and the major plant components including the reactor, the pipe, main coolant pumps and the steam generators.

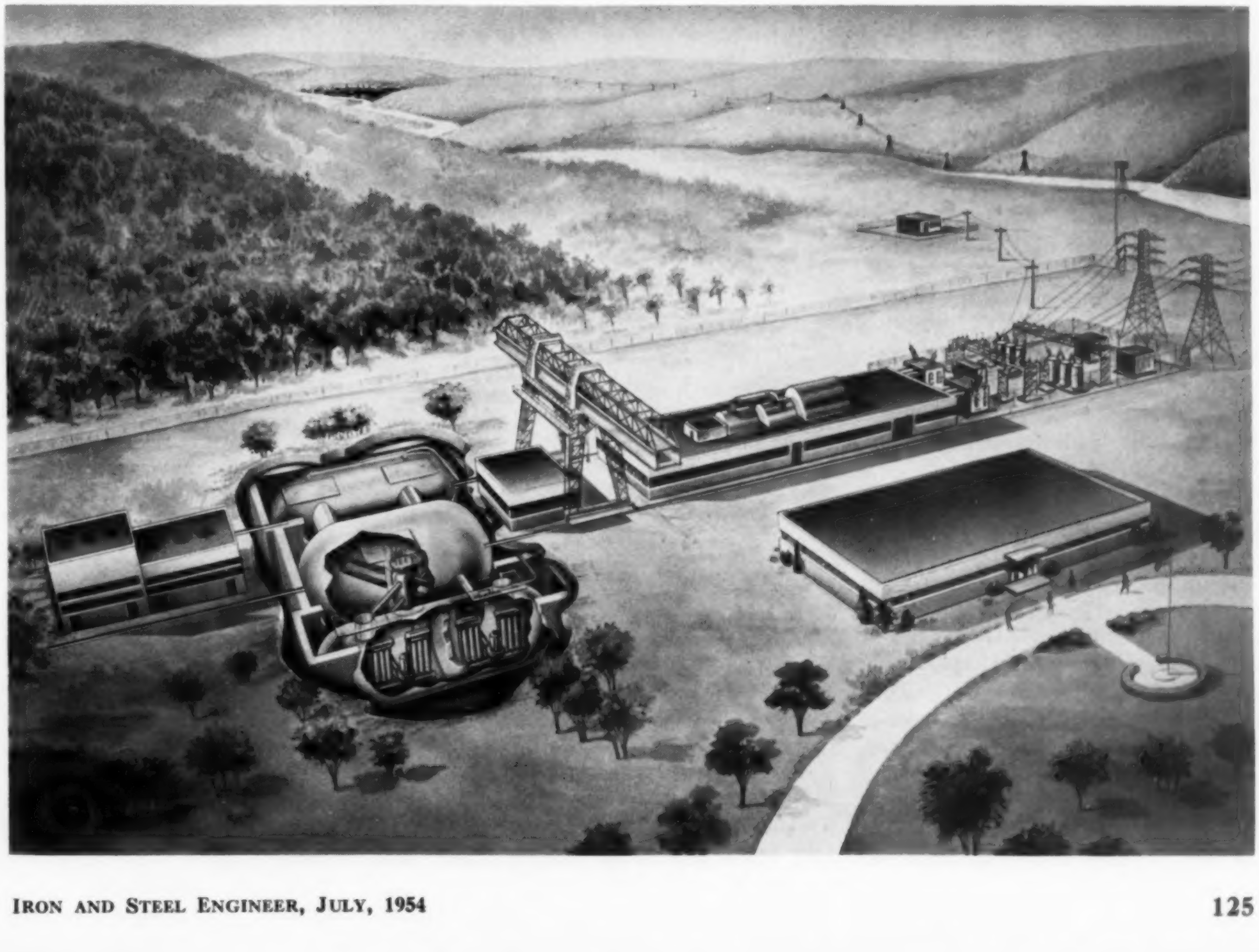
Figure 4 shows a preliminary artist's sketch of the over-all plant. The plant components depicted are, from the left: a building for fuel handling, the atomic reactor and heat exchangers, the maintenance building and overhead traveling crane, the turbogenerator building, the switchyard containing transformers and circuit breakers, and transmission lines. In the right foreground is a building containing shop and administrative facilities.

As can be seen from the cutaway view, the reactor which provides the heat, and the heat exchangers which generate the steam, will be located underground in concrete and steel structures. These underground structures will provide protection to operating personnel and the surrounding area in addition to the many protective devices in the reactor itself.

The field of power reactors stands today where the infant electrical industry stood some 75 years ago. There was then little doubt that the use of electrical power had a great future, but experts disagreed on whether electricity should be used in the form of direct or alternating current. Those who believed in alternating current could not agree on whether the frequency should be 25, 50, or 60 cycles. The pioneers in those days did not have accurate cost estimates; they could not project their problems accurately into the future; and it was difficult or impossible for them to predict how the many technical problems which faced them would be solved.

In the same way, those of us vitally concerned with nuclear power feel certain that it has an expanding place in the field of energy generation. But we lack the cost and technical data necessary to show that any one type of reactor is greatly superior to all others. We are still far from knowing how to solve all the many cost and technical problems which face each reactor type. In fact, the successful development of most reactors which now seem promising is sufficiently far ahead in the future that we are not

Figure 4 — The central station nuclear power plant is of the pressurized water reactor type.



able even to anticipate key technical problems which will arise. The low-enriched pressurized water reactor is today better understood than other types, and hence our problem of economics in building the PWR stands out more clearly. At Westinghouse we recognize these problems, but we are not discouraged by them. On the contrary, we believe that they can be solved in a way that will make this type of reactor economical.

Our experience to date on PWR has confirmed the difficulties of estimating the cost of a new reactor type without actually designing and building it. Recently we obtained, from the nation's most competent vendors, fixed-price sealed bids on the PWR steam generators and also on a prototype main coolant valve. Both bid invitations were based on complete performance specification. The bids received on each component varied by a factor of almost 5 to 1. With such variation in prices for the more conventional pieces of equipment, as quoted by qualified manufacturers, it seems clear that cost estimates on highly experimental items such as core fabrication and reprocessing are not estimates at all but merely guesses.

Those of us engaged in the design and manufacture of the PWR reactor can readily see how construction of this first plant will point the way to major reductions in both the capital and operating cost of later plants. As our technical requirements become better known, we can prepare firm specifications for all equipment and therefore benefit by competitive bidding across the board. As more experience is gained, we expect to reduce the need for such costly materials as zirconium and stainless steel. We are also confident of finding ways to eliminate the need for certain expensive safety devices.

As we learn more about the physics of slightly enriched water reactors and more about the technology of reactor materials, we know that we can bring about many-fold reductions in the costs of fuel processing. It will be necessary to build the first core largely by hand, ironing out manufacturing difficulties as they arise. Those of you familiar with manufacturing operations will recognize that process development is expensive and that it is not economical to tool-up for routine manufacturing until requirements are firmly established through experience. As time passes, however, we will unquestionably rely less and less upon hand labor and more and more upon automatic machines.

Furthermore, with additional knowledge and experience, we are sure that it will become possible to extend core life, thus reducing fuel costs by spreading fuel fabrication and reprocessing expenses over many more kilowatt hours. We anticipate finding ways of greatly decreasing the amount of uranium 235 used per kwhr.

We at Westinghouse believe in the wisdom of building a full-scale pressurized water reactor. We believe that the design minimum of 60,000 kilowatts is a sensible specification for the first plant, taking into account cost factors and the existing state of technology. Later plants will certainly be more economical at a higher power level. Likewise, we are glad that PWR is an all-civilian reactor, since this permits exploration of the pressurized water approach to industrial power without confusion or dilution either of the objective or the end results.

Enriched uranium is expensive, and so we have chosen to employ uranium of the least enrichment consistent with other technical considerations. Heavy water is expensive, and its limited advantages, in our opinion, do not offset the extra cost; hence we have chosen to use ordinary water. Fuel reprocessing is expensive, and we therefore seek the longest attainable life span for each core loading and in addition we are striving for the maximum use of converted material. This objective calls for high fuel burnup including burnup of the plutonium produced as our reactor operates. The PWR will be a converter, that is, it will convert fertile material to fissionable material in the core.

No one has ever built a power reactor like this before. The slight enrichment, the long core life span, the deliberate intent to burn plutonium after it is generated through reactor operation, the use of ordinary water in conjunction with the other features, and additional matters which we are not at liberty to disclose — each of these objectives, considered separately, is without precedent, at least in the free world. Considered in the aggregate, they mean that we are struggling to take a long stride into the unknown.

As we know more about reactors of this type, more and more of the power will come from burning plutonium generated in the reactor after operations commence. In fact, there is no reason, in principle, why pressurized water reactors cannot become breeders. However, trying to build such a feature into Plant Number One, along with all the other unprecedented features, would tack on years to the completion date.

I have heard it claimed that building an H-bomb is a tougher job than building an A-bomb — but that the scientists could not even consider the H-bomb unless they had first acquired A-bomb experience. This is our situation with the PWR. Developing it will present many tough problems; but we could hardly even dream about a practical, attainable PWR without our previous experience in building pressurized water submarine plants.

At the same time we do not claim to know, and we do not believe anyone can justly claim to know, which reactor type will ultimately turn out to be most satisfactory. In fact what is considered the *best* plant will certainly vary with time. Certainly very few techniques in any field have maintained a *first* position over extended lengths of time. As a nation we are still only scratching the surface of atomic power technology. The evidence required for any sort of solid judgment is just plain lacking. For this reason we welcome the Atomic Energy Commission's recently announced five-year program for industrial power reactor development. The commission's policy of exploring the five approaches that seem most promising today is certainly right; for this is the only practical way to find out the advantages and disadvantages of each. If any of the techniques after evaluation appear practical we trust they will be followed by large-scale plants as in the case of the PWR.

As the Government contractor for development of the PWR, we at Westinghouse would be less than human if we did not feel a sense of adventure, as well as heavy responsibility, in carrying forward this major attempt both to advance the reactor art and to harness the atom for electricity.

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1 Protect against short-circuits. **2** Protect against needless blows caused by harmless overloads. **3** Protect against needless blows caused by excessive heating — lesser resistance results in cooler operation. **4** Provide thermal protection — for panels and switches against damage from heating due to poor contact. **5** Protect motors against burnout from overloading. **6** Protect motors against burnout due to single phasing. **7** Give DOUBLE burnout protection to large motors — without extra cost. **8** Make protection of small motors simple and inexpensive. **9** Protect against waste of space and money — permit use of proper size switches and panels. **10** Protect coils, transformers and solenoids against burnout.

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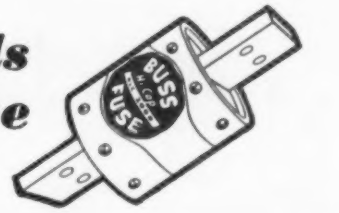

Tests have shown that BUSS Hi-Cap fuses have unlimited interrupting capacity on circuits of 600 volts or less.

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. . . . research techniques used in these aluminum studies can also be applied to other metals . . . .

▲ RADIOACTIVE tracers are being used by Aluminum Co. of America as a powerful new tool in research studies.

These tiny tracers have previously been used in medical applications, pharmaceutical uses and in the chemical industry. Such diverse uses as cancer research, metabolism studies, thyroid treatment, drug sterilization and process control devices are included in these general fields.

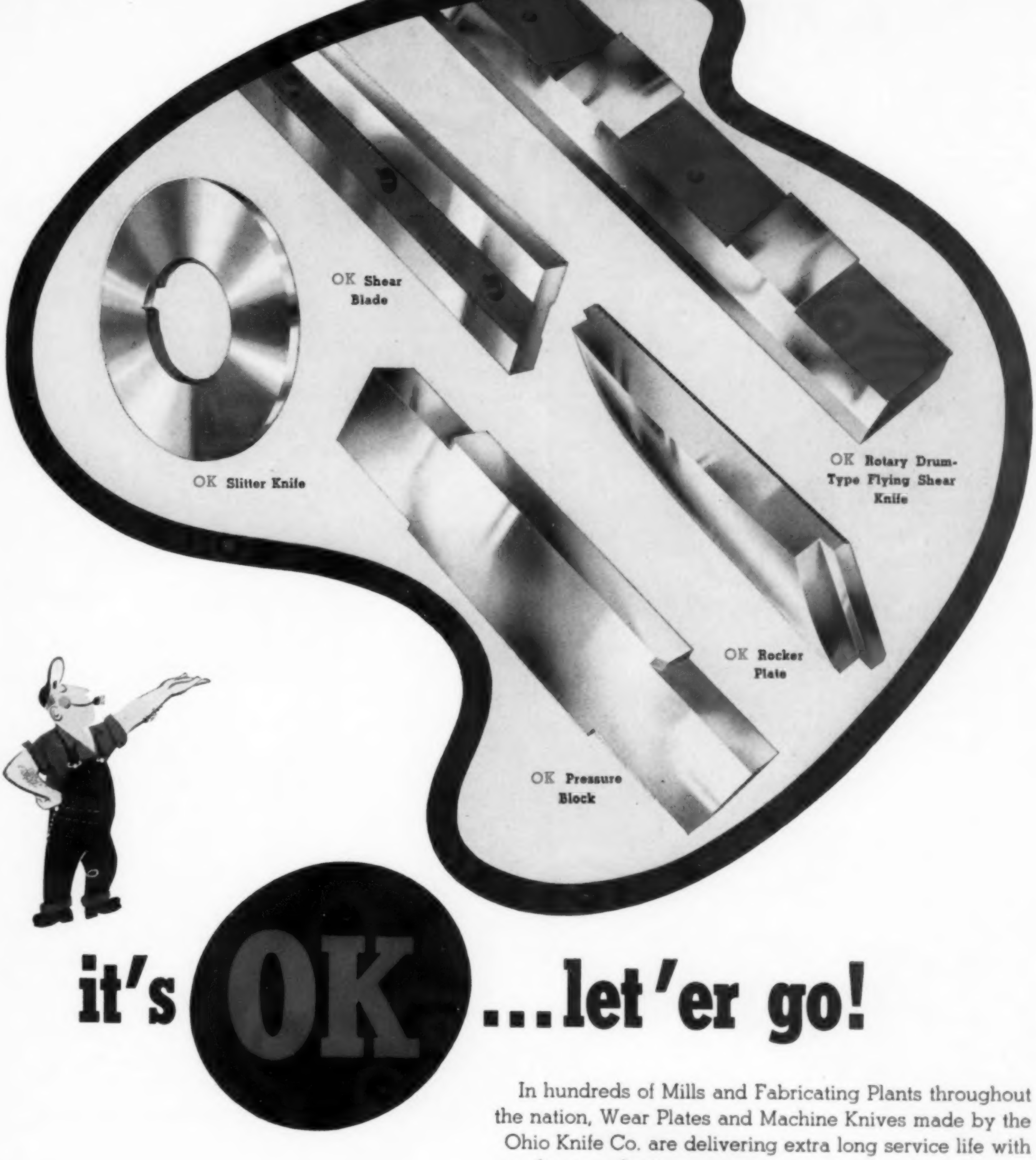
Alcoa researchers are using radioactive tracers in lubricant evaluation, corrosion resistance studies, analytical chemistry, alloy development, metal flow during the extrusion process, and many other projects. The method is also applicable to studies of flow of metals during rolling, a subject of particular interest to the steel mill engineer.

A sample containing radioactive material is placed in a lead shield which surrounds a Geiger tube. The rate of emission of radiation by the sample is measured electronically and recorded. This determination is a basic step in all tracer work.

Radioactive tracers are usually tiny bits of material made radioactive by the Atomic Energy Commission at Oak Ridge, Tenn. This material is then mixed, alloyed or combined with materials to be tested. The activated bits of material can be traced through complicated steps with sensitive instruments.

Alcoa's Aluminum Research Laboratory is one of the first in the Pittsburgh area to utilize radioactive tracers in metallurgical research, and has one of the most diversified radiochemical programs in the nation.

In the field of lubricant research, by using radioactive material, Alcoa's men have been able to measure the wear on bearings more accurately and to a much finer degree than was possible by other means. These measurements are made possible by first making bearings radioactive after which they are placed in a normal working situation. The wear data are then obtained by measuring the amount of radioactive material that is present in the oil bath covering the activated bearing after a period of use. In tests completed at the lab-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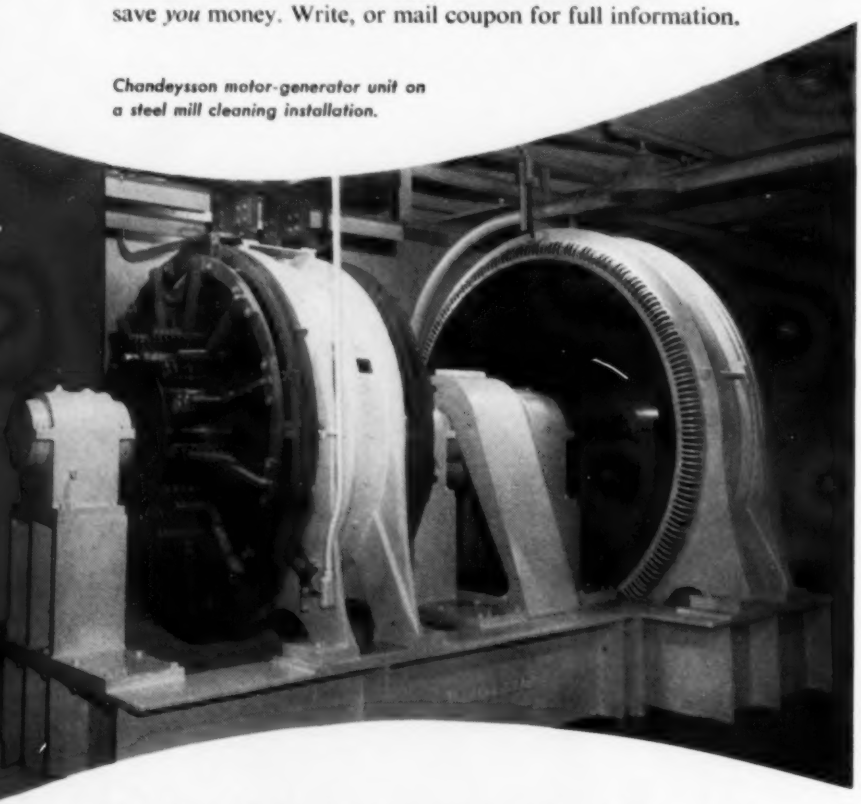

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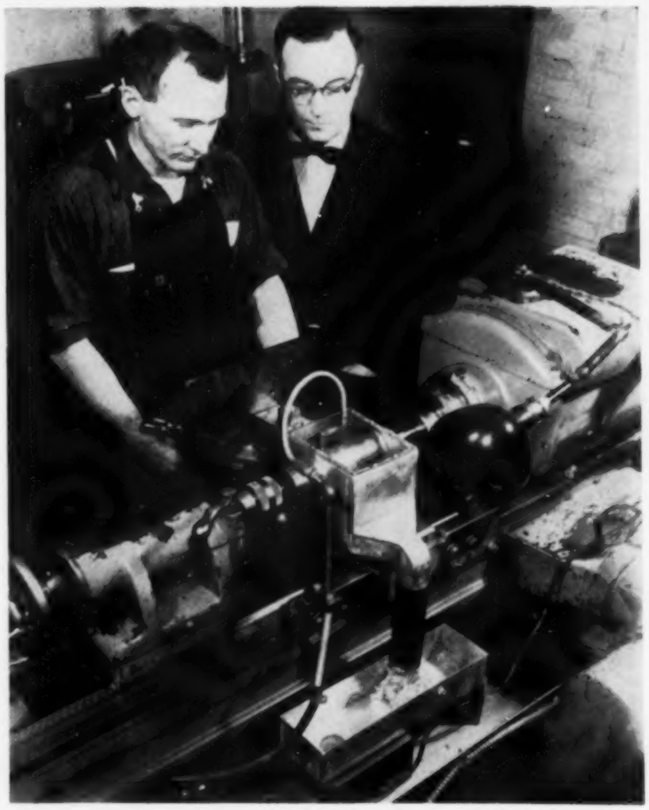
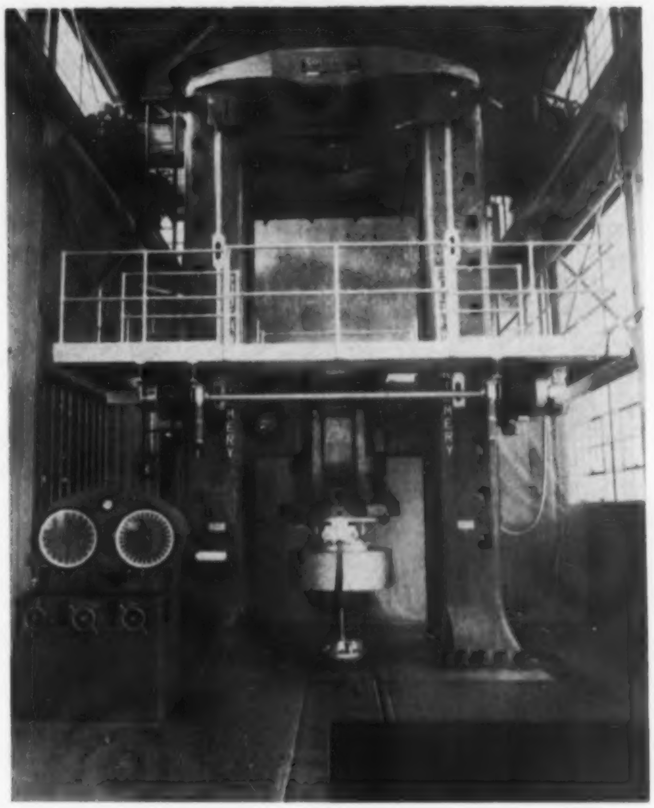


An aluminum cylinder with a radioactive cutting tool is being machined. The very slight wear of the cutting tool in only two revolutions of the lathe can be detected by the amount of radioactive tungsten in the aluminum chips. The closed box is to confine the radioactive chips. The operators wear pocket dosimeters to measure the amount of radiation reaching them from the tool bit.



The precision metal working machine is equipped to direct extrude ¾-in. diameter rod. A machined extrusion ingot, into which a radioactive plug has been inserted, is placed on the ram that is bolted to the base. The movable head, cylinder, and furnace containing the die assembly are lowered over the ingot and ram. A ¾-in. extruded rod emerges from a 10-in. guide hole through the crosshead and is received by an attendant on the elevator platform.

oratory, excellent wear data were obtained in the microinch range (1 microinch equals 0.000001-in.)

In the corrosion studies, a piece of metal is immersed in a corroding solution that contains a trace (as little as 0.05 rpm of radioactive material). After a brief exposure, the metal is taken from the solution and a check made by Geiger counter. This procedure gives an accurate count of the corrosion material pick-up. Even a photograph of the corrosion areas can be made by placing the metal on a special film emulsion. This film is sensitive to the rays of the radioactive material.

A promising metallurgical application of radioactive tracers is in the study of metal flow during the extrusion of aluminum alloys. Extrusion is limited by slow speeds on hard alloys and the difficulty of obtaining smooth surface finish on the less hard alloys.

By using radioactive tracers, scientists are now able to determine the detailed characteristics of the flow of any small regions of an ingot, in the extrusion process. This information can be used to develop techniques for making higher quality aluminum extrusions more economically. Such items as flow patterns, temperature, force distribution, and other similar basic information should be known.

In order to study the flow pattern, tiny pieces of aluminum alloy, made radioactive in the pile at Oak Ridge, are placed into holes drilled in the ingot. This ingot is homogenous since the radioactive alloy differs in no chemical or metallurgical respect from the remainder of the ingot.

After the ingot is extruded, the flow of metal from the regions "tagged" by the thread of radioactive material can be accurately established by measuring the activity of extruded sections with a Geiger counter. Exact location of the thread can be established by placing a cross-section of the extruded part on a photographic film so that it will take its own picture.

Although radioactivity is not new, the production of enough radioactive substances for convenient use had to wait for the development of the chain-reaction neutron piles. When a substance is placed in a neutron pile at Oak Ridge, it is bombarded by a large number of subatomic particles called neutrons. More than three trillion of these neutrons pass through each square inch a second. Occasionally, one makes a direct "hit" on the core or nucleus of the substance that is being bombarded. This nucleus then becomes radioactive, and the radioactivity becomes apparent when the substance "decays" and gives off its excess energy in the form of high-energy radiation. This radiation is similar in its effects in many respects to X-rays. Being radioactive, this material is thereby capable of being traced with special sensitive instruments even when mixed or alloyed with other materials.

These electronic instruments are so sensitive that even extremely small amounts of radioactivity can be measured. With suitable precautions, such as adequate shielding, there is no danger to the health of those involved in this program.

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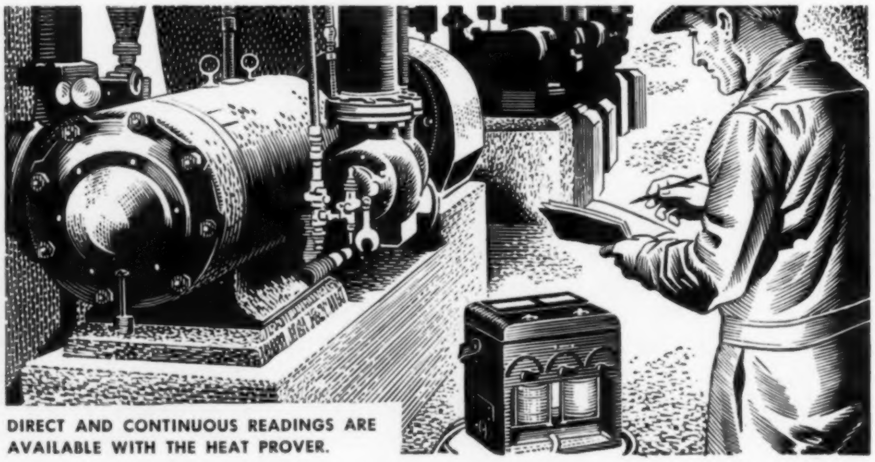

DIRECT AND CONTINUOUS READINGS ARE AVAILABLE WITH THE HEAT PROVER.

NATIONAL BUREAU OF STANDARDS STUDIES REFRACTORY CASTABLES

▲ REFRACTORY castables are heat-resistant concretes consisting primarily of a refractory aggregate, such as crushed firebrick, bonded together with a high-alumina hydraulic cement. Initial strength is developed because of the setting of the water-cement mixture; but if the castable is used at high temperatures, its ultimate strength will be due to fusion of the cement into a ceramic bond.

To meet the need for comprehensive data on refractory castables, the National Bureau of Standards has been conducting a long-range investigation of these materials for several years. Recently a study was completed which provides additional useful information on the properties of the castables and the effects produced by different types of heat treatments. The results are based on laboratory-prepared mixes as well as on representative commercial castables and include data on both a domestic and an imported refractory cement.

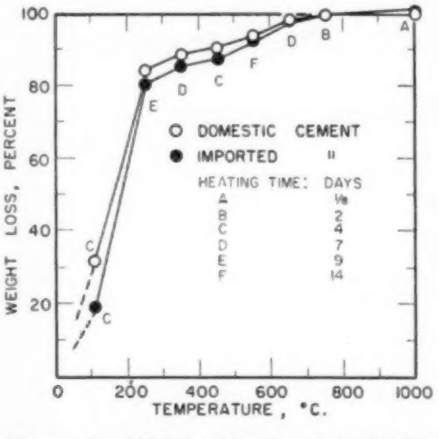

Figure 1 — Weight of water lost during the heating of hydrated high-alumina hydraulic cements. Heating times required to reach constant weight at each temperature were (A) 1/8 day, (B) two days, (C) four days, (D) seven days, (E) nine days, and (F) 14 days. Open circles indicate domestic cement; closed circles represent imported cement.

Two different aggregates, crushed calcined flint clay and crushed fire clay brick, were used in the laboratory-prepared castables, and each aggregate in turn was combined with each cement. The commercial castables totaled 16 which had been submitted by manufacturers for study. Properties such as flow of the wet mixes, particle-size distribution, and strengths in compression, tension, and flexure after curing were investigated. After the specimens had been heated for periods up to 12 months at a number of temperatures ranging to 1350 C, the resulting permanent linear changes were measured, and strengths in compression, tension, and flexure after curing were determined. Specimens were of three types: 2-in. cubes for compressive strength tests, 2 × 2 × 10-in. bars for modulus-of-rupture determinations, and figure-eight shapes for tensile tests. For most of the measurements or the laboratory-prepared castables, batches containing 10, 20, and 30 per cent cement were utilized.

Although the pyrometric cone equivalent of the commercial castables ranged from 14 to 37, most had a refractoriness below cone 18, which corresponds approximately to a softening temperature of 1490 C. The loss in strength for both laboratory-prepared and commercial castables was more pronounced from room temperature through the heat treatment at 300 C than it was thereafter at various higher-temperature treatments through 1050 C. The ceramic bond apparently began to develop for most of the castables with heat treatment at 1125 C. In general, the strengths of the castables were higher after a one-month heat treatment at 900 C than when heated for five hours at 900 C. However, for laboratory-prepared castables heated at 300 C, the compressive and transverse strengths after heating for eight or 12 months were not significantly different from those obtained after a four-month heat treatment.

Microscopic examination indicated no apparent changes in structure after the castables were heated to 1050 C. However, after heating at 1300 or 1350 C, reaction rims around the particles of flint-clay aggregate were strongly in evidence. Also, the smaller particles of aggregate had turned completely brown in color during the course of the reaction, probably because of the absorption of iron oxide in the cement.

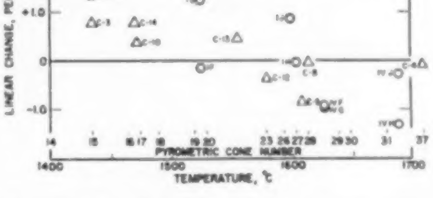

Figure 2 — Relation between pyrometric cone equivalent, an index of refractoriness and linear change of refractory castables heated at 1300 C (closed circles and triangles) or 1350 C (open circles and triangles). Data for the laboratory-prepared castables are represented by circles while the commercial castables are indicated by triangles. The letters and numbers adjacent to plotted points refer to particular types of castables. For the laboratory-prepared castables, the symbols IV, I, III indicate 10, 20 and 30 per cent cement, respectively. The scale of softening temperatures corresponding to the pyrometric cone equivalents is given for reference only.

After heating four months at 300 C, the shrinkage of all compositions was small, in most cases about 0.1 per cent. Additional heating at 300 C for a total of eight months doubled or tripled the shrinkage, but the total remained small. For most specimens there was little increase in shrinkage between eight and 12 months' heating. When the castables were heated at 1300 or at 1350 C for five hours, those with a pyrometric cone equivalent of 20 or below generally expanded while those with a PCE above 20 shrank.

At the end of four months at 300 C, the porosity of the castables containing the fire-clay brick aggregate (porosity 20.9 per cent) averaged 30 per cent, whereas those containing the flint clay averaged from 27 to 28 per cent. After heating at 300 C for a total of six months, the porosity was slightly lower for all but two of the compositions.

Specimens were also prepared from the two hydrated cements without aggregates and their weight losses after heat treatments at a series of increasing temperatures were determined. It was found that the hydrated cements lost about 80 per cent of their free and combined water after heating nine days at 250 C (Figure 1). The remaining water was more tenaciously held and was not removed until an additional 34 days had elapsed and the cements had been heated at 750 C. Thermal analysis curves of the hydrated cements showed endothermic deflections at about 110 C and 280 C and an exothermic deflection at approximately 900 C. The two endothermic reactions may be attributed to the loss of water of hydration while the exothermic reaction may be due to the crystallization of amorphous alumina.

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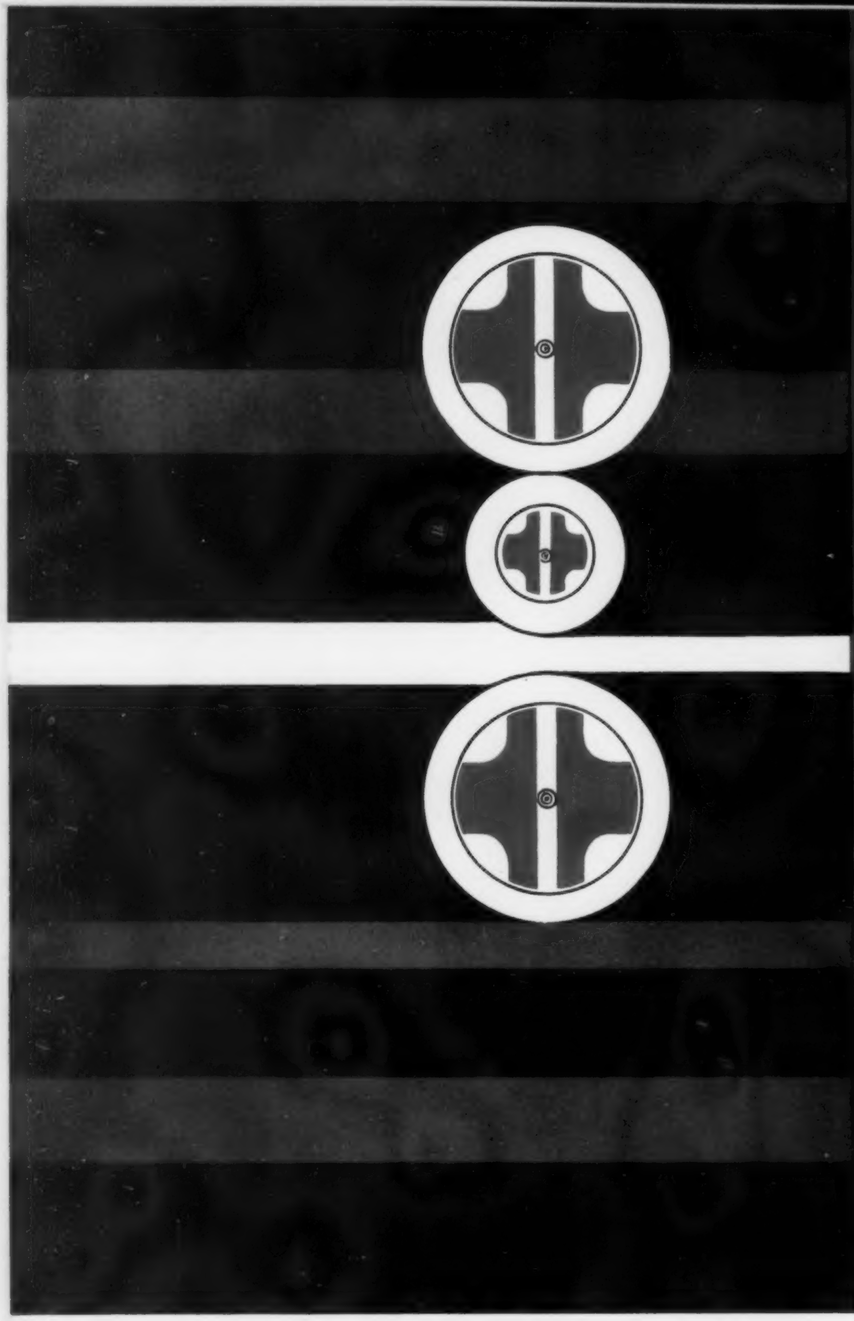

MACK-HEMP striped red wabbler rolls have what it takes for PLATE MILL productioneering

There's a Mack-Hemp roll with just the right physical and metallurgical characteristics for every plate mill requirement—whether for roughing or finishing.

In heavy roughing applications cast steel TECHNALLOY rolls *have what it takes* to maintain rolling schedules.

Strong and tough Mack-Hemp NIRONITE rolls have the fine grain structure you need for intermediate and finishing passes.

And for mills rolling floor plate there's MIDLAND SUPERALLOY, a special alloy roll with the controlled hardness so essential to good product finish.

But the important thing to remember is that Mack-Hemp makes rolls for every type of mill, rolling any kind of rolled-metal products. That's why you can always be sure of the best rolls for low cost operation just by keeping an eye on what's new at Mack-Hemp.

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Makers of the Rolls with the Striped Red Wabblers

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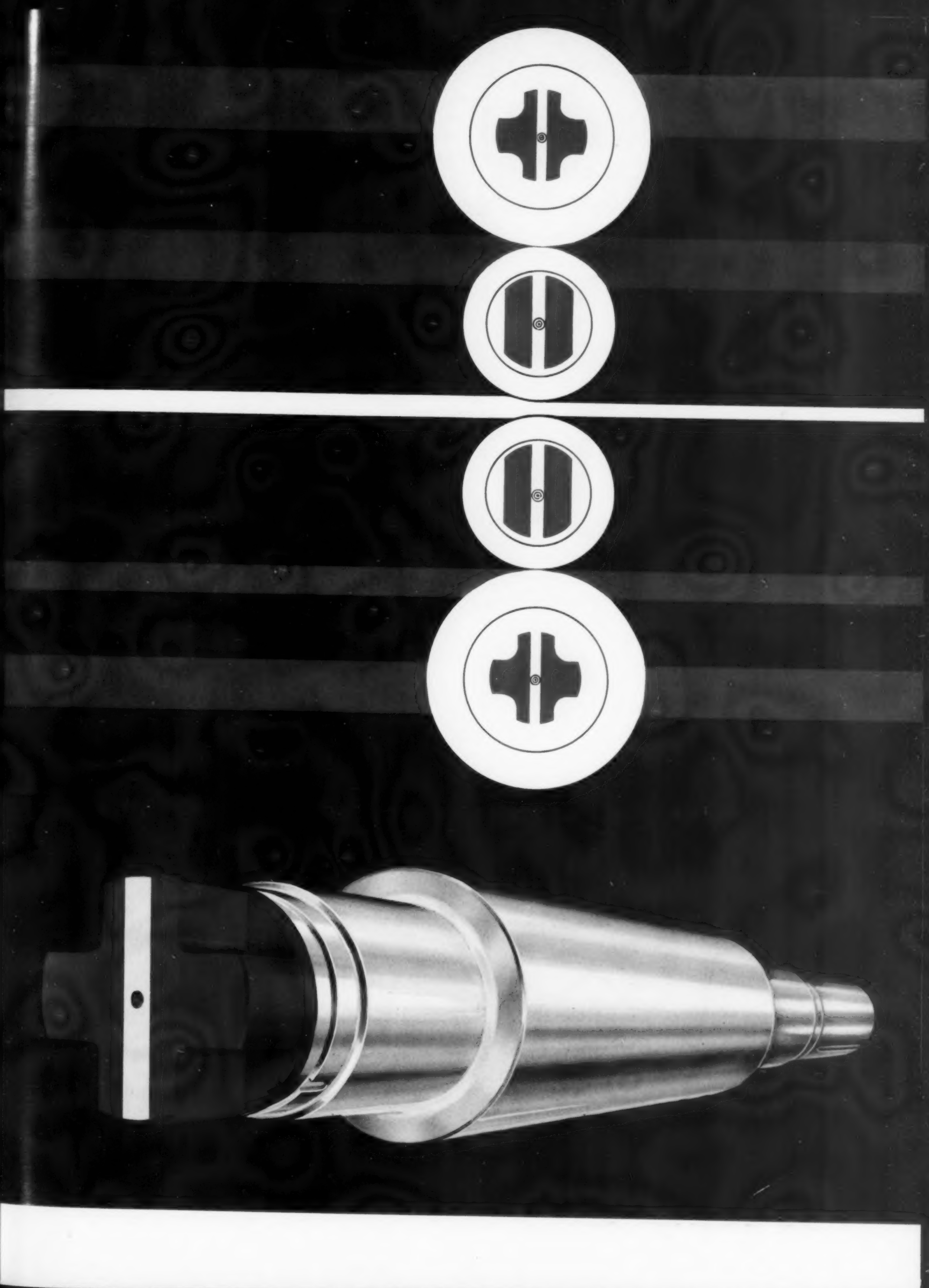

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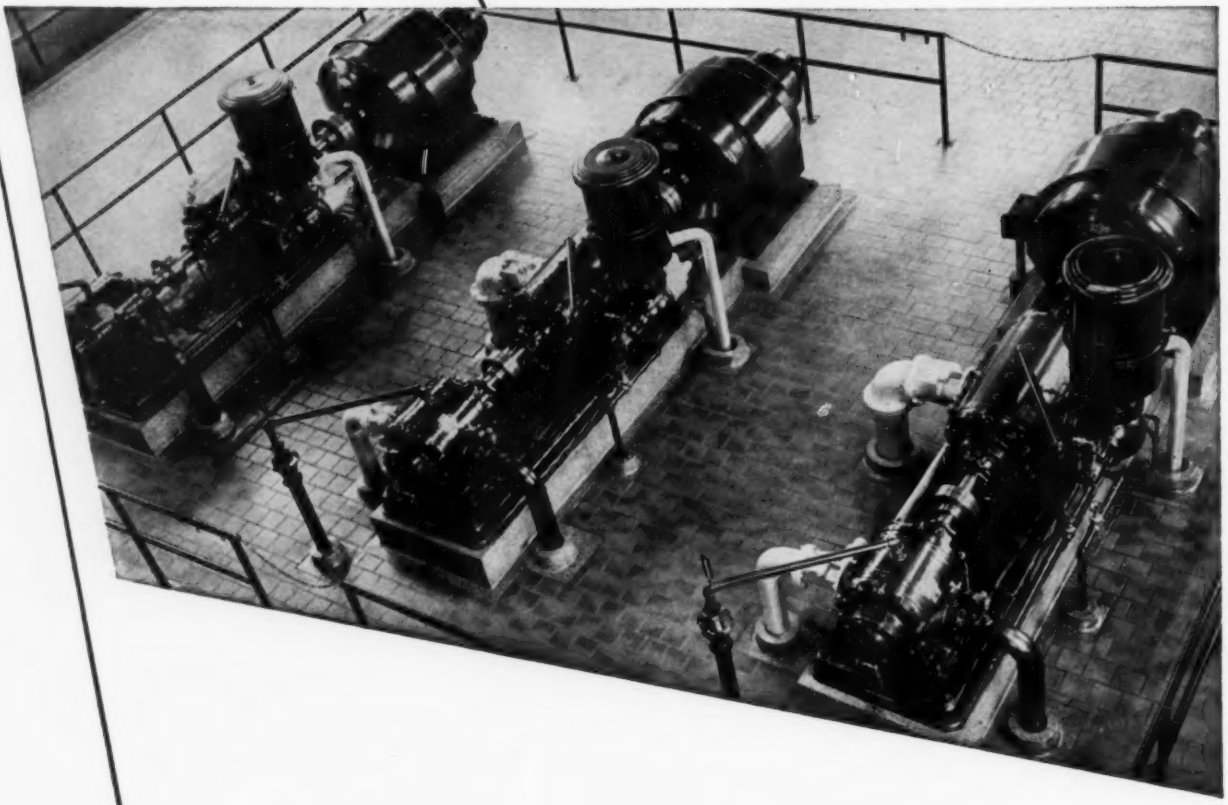
HEAVY FOUNDATION COSTS
WHEN YOU INSTALL
Fuller Rotary Compressors



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C-228

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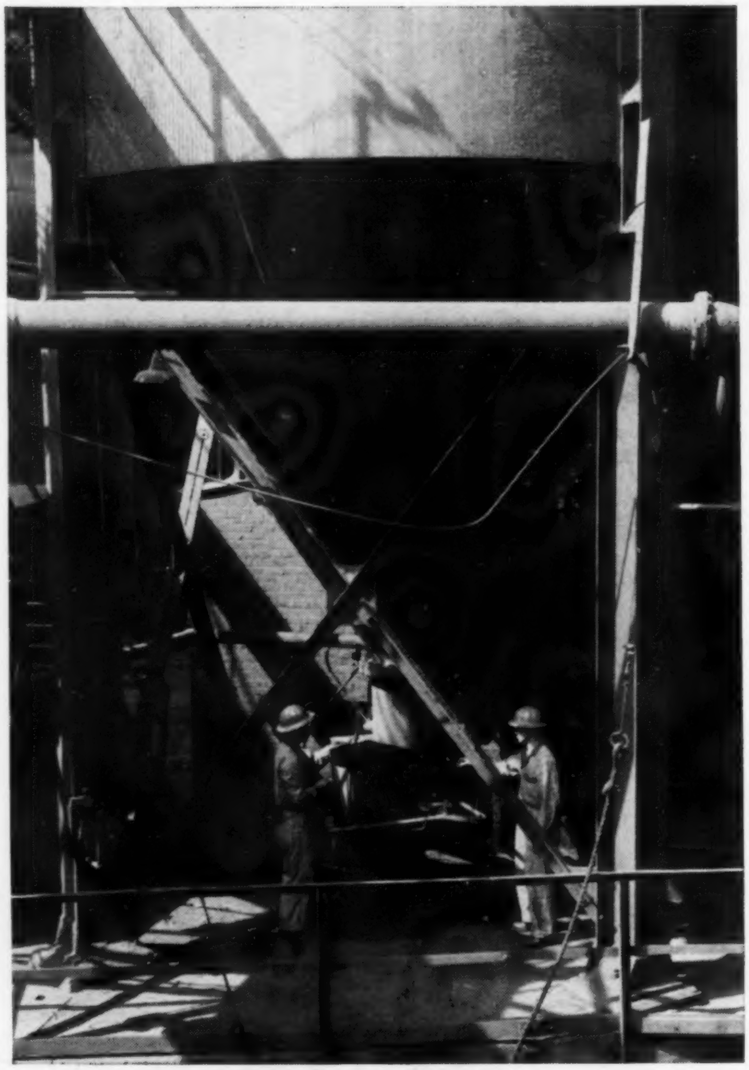
Free Bulletin on Chemical Cleaning for Steel Mill Equipment

For your convenience, we have prepared an informative bulletin that tells you about the chemical cleaning of many different kinds of steel mill equipment by Dowell Service. For your free copy, write today to Dept. G29, Tulsa, Okla.



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Date-line Diary...

June 2

▲ Installment credit outstanding moved up $9,000,000 during April as compared with a $376,000,000 rise during April 1953. This reversed the downward trend for the first quarter of 1954 when credit outstanding decreased by $900,000,000, according to the Federal Reserve Board.

▲ The House passed a bill increasing Social Security benefits and extending coverage to an additional 9,700,000 persons. No change in rate is anticipated until 1970.

▲ The Senate passed a resolution calling for another year's operation of the Government's tin smelter in Texas City, Texas bringing the date to June 30, 1955.

June 3

▲ McLouth Steel Corp. put into operation a new 200-ton electric furnace, the world's largest electric unit. A second unit is expected to be ready by June 15.

▲ General Motors, Chrysler Corp. and Ford Motor each reported a decline in May production from the previous month.

▲ Lead advanced ¼¢ to 14¼¢ a lb in New York and to 14.05¢ in St. Louis.

▲ Youngstown Sheet and Tube Co. announced plans to construct a new 76-oven coke by-products battery at its Campbell works in Youngstown, Ohio estimated to cost $9,000,000 to $10,000,000. The new battery will have a capacity of 1250 tons of coke per day.

June 4

▲ The Commerce Dept. estimated personal income for April declined to an annual rate of $282,000,000,000. This was $900,000,000 below March and $700,000,000 below April 1953.

▲ Zinc advanced ½¢ to 11¢ a lb in East St. Louis bringing zinc to its highest price since September 1953.

▲ Net income of class I railroads for the first four months of 1954 fell to $128,000,000, down $134,000,000 from the same period in 1953.

June 7

▲ The AISI reports that operating rate of the steel industry for the week starting June 7 is scheduled at 73.0 per cent of capacity. This is equivalent to 1,740,000 tons compared with 1,674,000 tons one week ago and 2,208,000 tons one year ago. Index of production for the week is 108.3.

▲ The Aluminum Association reported primary production of aluminum in April 1954 was 240,867,314 lb as compared with 244,678,349 lb in March and 204,142,768 lb in April one year ago.

▲ According to figures of the Commerce Dept., business inventories and stocks were reduced sharply in April.

▲ Due to aircraft manufacturers' aluminum requirements falling below what was originally estimated, the Government will cancel its aluminum expansion which called for an additional 215,000 tons production capacity. Production of aluminum, with Government assistance, will rise to 403,000,000 lb in the June quarter compared with 261,000,000 in the first 1954 quarter.

▲ Republic Steel Corp. will acquire Cleveland Chain and Manufacturing Corp. which has a total employment of 1000. Chief customers of this firm are shipping and lumber industries, auto and truck makers.

June 8

▲ The Supreme Court has ruled that sales of natural gas by Phillips Petroleum Co. to interstate pipeline companies are subject to FPC control. This covers 2300 natural gas producers.

▲ Unemployment stood at 3,305,000 the week ending May 8, a drop of 160,000 from April, according to the Commerce Dept.

▲ Construction outlays in May rose to a new high of $3,100,000,000, 10 per cent higher than April and 4 per cent higher than May 1953, according to the Labor and Commerce departments.

▲ On net sales of $406,537,000, net earnings of $26,286,000, equal to $1.61 per common share, were disclosed by Westinghouse for the first three months of 1954.

▲ Prices of structural steel shapes and carbon steel plates were lowered by Central Iron and Steel Co. of Harrisburg and Phoenix Iron and Steel Co. of Phoenixville, Pa. Cuts amounted to $7 a ton on wide flange and standard shapes and $5 on plates.

June 10

▲ The Aluminum Association reported primary aluminum production in the United States for May 1954 totaled 250,175,582 lb as compared with 240,867,314 lb for April and 210,953,111 lb for May one year ago.

June 11

▲ New car stocks for auto dealers declined in late May for the first time in six months. New car sales the last ten days of May were 8 per cent above the daily rate in April.

▲ New unemployment claims for the week ending June 5 declined for the fourth week in a row dropping to 186,548, down 1432 from the preceding week.

June 14

▲ The AISI reports that operating rate of the steel industry for the week starting June 14 is scheduled at 73.5 per cent of capacity. This is equivalent to 1,752,000 tons compared with 1,746,000 tons one week ago and 2,183,000 tons one year ago. Index of production for the week is 109.1.

▲ According to the Labor Dept., unemployment fell to 1,966,043, off 112,700 from one week earlier.

June 15

▲ Management of the New York Central Railroad was taken over by Robert R. Young who had defeated the Central's management forces by around 1,070,000 votes.

▲ The Commerce and Labor Depts. predict that construction outlays in 1954 will reach an all-time high of $36,000,000,000 which is 2 per cent above the previous high set in 1953.

▲ United States exports of commercial goods in the first four months of 1954 totaled $4,100,000,000, one per cent higher than the same period one year ago.

June 16

▲ United States Steel Corp. rejected Steelworkers' demands for wage increases but has offered to modify the union's request for improved pension and social security benefits.

▲ The ICC will begin hearings on June 28, on problems of Pennsylvania, B & O, Erie, Lackawanna, Nickel Plate, and Wabash railroads which involved the moving of highway trailers by rail. It postponed such service for the time being.

June 17

▲ The F. W. Dodge Corp. reported contract awards in May for future construction in the 37 eastern states reached a total of $1,925,253,000, a new monthly record. This was 14 per cent above April and 20 per cent above May 1953.

▲ Deliveries of new domestic freight cars in May 1954 totaled 3173 compared with 4038 in April and 6582 in May 1953, the ARCI announced. Orders in May totaled 1071 leaving a backlog on June 1 of 15,615.

June 18

▲ The Atomic Energy Commission will negotiate a contract for 600,000 kw of electric power over a 25-yr period with Middle South Utilities, Inc. and the Southern Co.

June 21

▲ The AISI reports that operating rate of the steel industry for the week starting June 21 is scheduled at 72.6 per cent of capacity. This is equivalent to 1,731,000 tons compared with 1,725,000 tons one week ago and 2,183,000 tons one year ago. Index of production for the week is 107.8.

June 22

▲ The Federal Reserve Board will cut reserve requirements of member banks by $1,500,000,000 making possible a credit expansion of $7,500,000,000.

▲ The Electro Metallurgical Co. division of Union Carbide and Carbon Corp. plans to build a $30,000,000 titanium plant at Ashtabula, Ohio. The plant will have a 10,000-ton annual sponge-making capacity and will be one of the world's largest such plants.

June 23

▲ Republic's new delivered pricing method will be extended July 1 to cover small shapes, new billet concrete reinforcing bars, plates and structural shapes.

▲ The United Steelworkers rejected as unsatisfactory the improvements in pension and insurance programs which were offered by United States Steel Corp.

▲ Studebaker Corp. and Packard Motor Car Co. will combine into one concern to be called Studebaker-Packard Corp.

▲ The AISC reported May bookings of fabricated structural steel amounted to 200,994 tons, an increase of 9 per cent above April. Bookings during the first five months of 1954 totaled 1,023,839 tons, around 300,000 tons less than the corresponding period of 1953. Shipments in May were 254,098 tons leaving a backlog on June 1 of 1,489,662 tons.

June 25

▲ United States Steel was considering upward revision of its contract proposals in an effort to avert a walkout on June 30.

▲ Engineering construction awards for the week ending June 24 amounted to $313,000,000, as reported by the Engineering News-Record. This was slightly below the week previous to this, but $63,000,000 above the same period in 1953.

▲ Birdsboro Steel Foundry and Machine Co. has agreed with Fredrick W. Richmond of New York City to sell all the assets of the company for $3,970,000, or around $20 per share of outstanding stock. The company will continue in its present locations and will operate with its present management and personnel.

June 28

▲ The AISI reports that operating rate of the steel industry for the week starting June 28 is scheduled at 67.0 per cent of capacity. This is equivalent to 1,597,000 tons compared with 1,720,000 tons one week ago and 2,069,000 tons one year ago. Index of production for the week is 99.4.

▲ Auto makers are pushing sales to reduce unsold stocks before fall when 1955 models will be out. Stocks on June 10 amounted to 647,000 units which is 44 per cent higher than one year ago.

▲ Railroads urged the ICC to continue further experimentation in the movement of highway trailers by rail flatcars.

▲ A settlement with the United Steelworkers of America providing for improved insurance and pension benefits and a wage increase of 5¢ per hr was announced by Clifford F. Hood, president of United States Steel Corp.

▲ Benjamin F. Fairless, chairman of the board of directors of United States Steel Corp., announced that the corporation proposed to sell $300,000,000 serial debentures maturing in one to ten years.

June 30

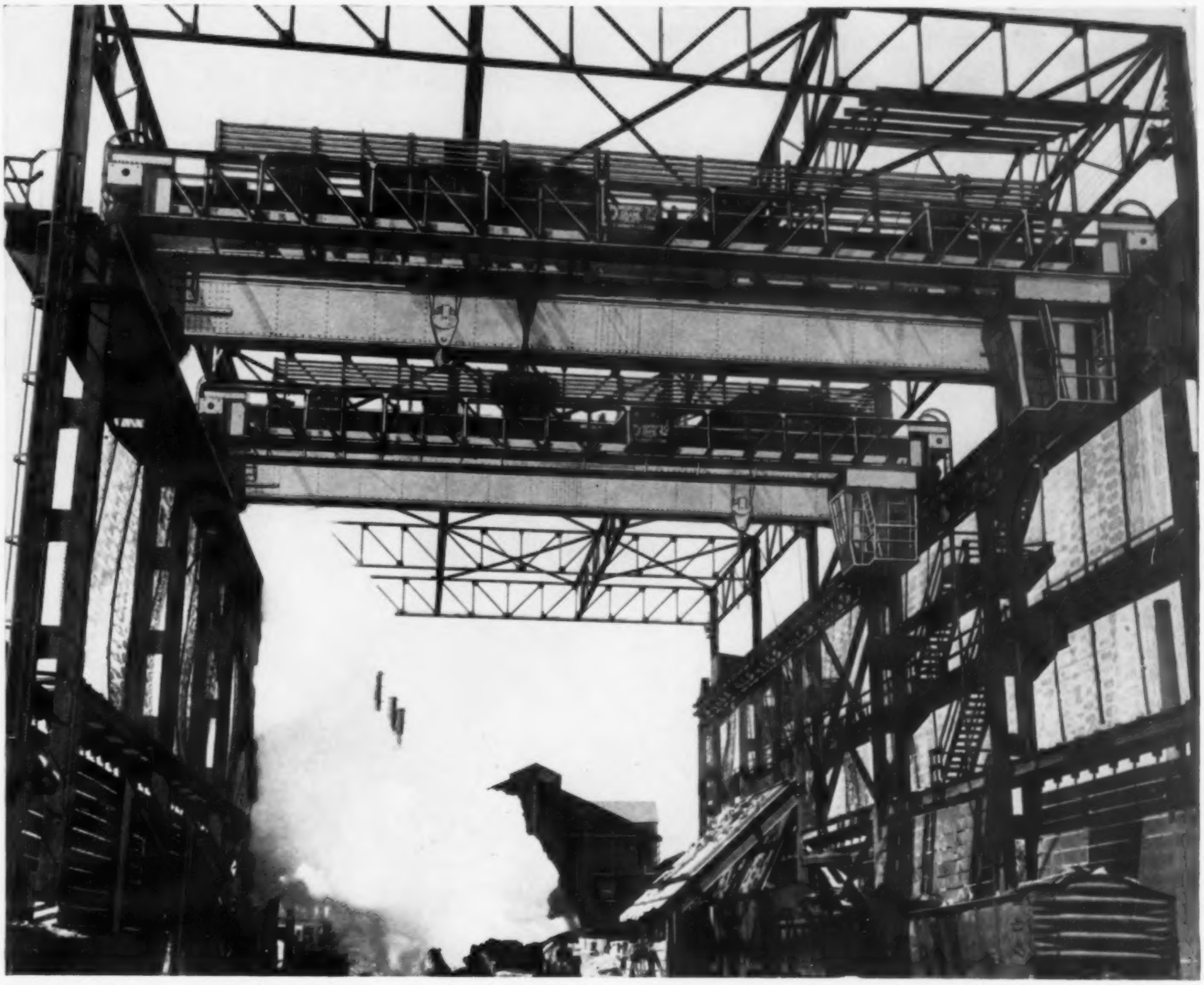
▲ U. S. exports of commercial goods for May totaled $1,100,000,000 which is $40,000,000 above one year ago.

▲ The House approved the bill to continue copper duty suspension an additional year. The present suspension of duty expires today.

▲ The proposed international tin agreement which is designed to bring supplies of tin into balance with world demand was signed by five more nations, namely, Turkey, Australia, Denmark, Canada and Ecuador.

▲ The Senate voted tentatively to cut in half the plan to ease double taxation of corporate dividends and also rejected the amendment to provide a $20 tax credit for each taxpayer.

▲ According to B. F. Fairless, chairman of U. S. Steel Corp., steel prices must be raised to compensate for the higher wages and improved benefits granted the CIO United Steelworkers.



Two 30 ton, 75 ft. span Bedford magnet cranes with 15 ton bucket auxiliaries working over the cinder yard — used as skull crackers in Detroit Steel Corporation's mill at New Boston (Portsmouth), Ohio.

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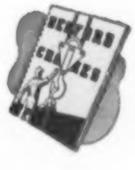

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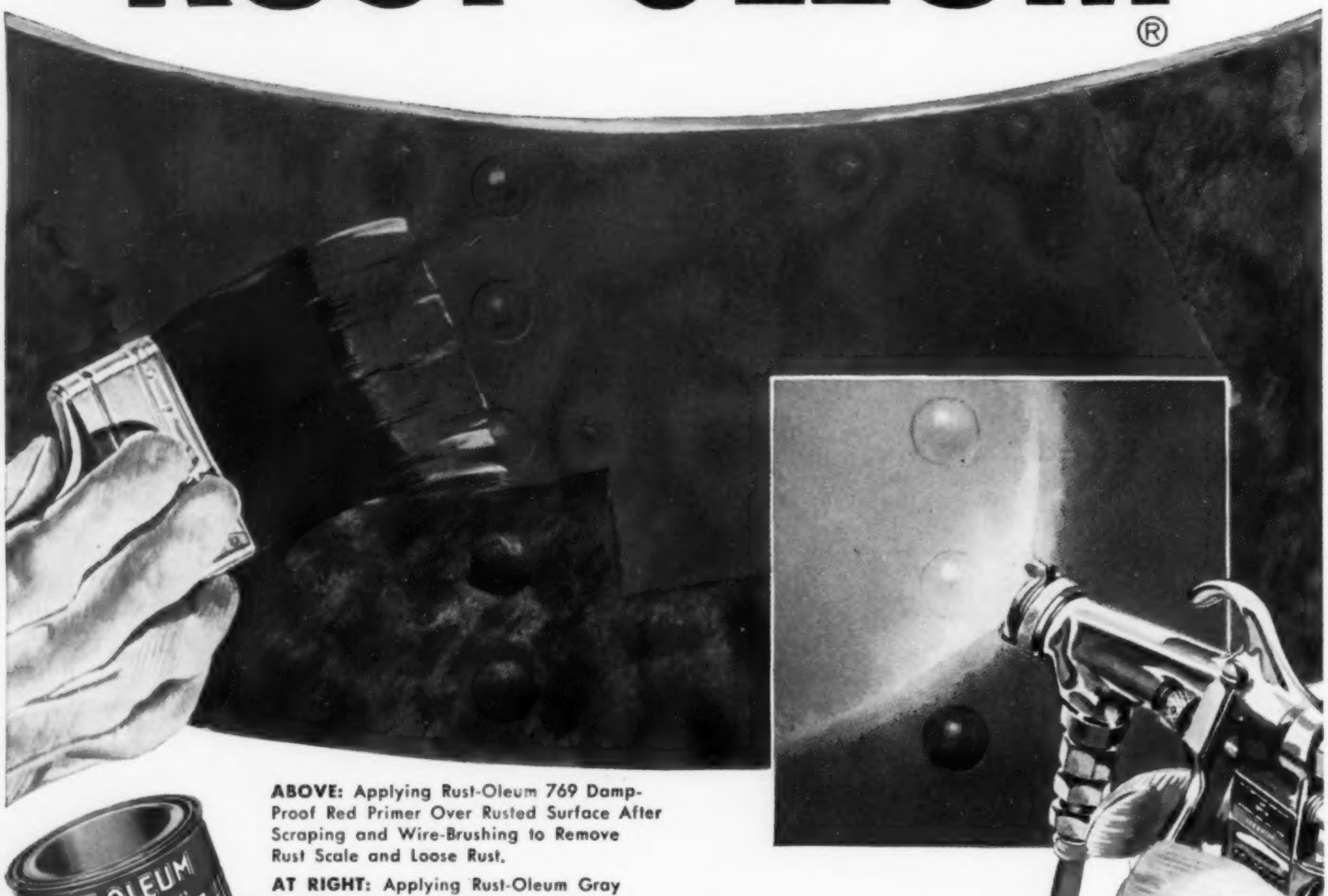

ABOVE: Applying Rust-Oleum 769 Damp-Proof Red Primer Over Rusted Surface After Scraping and Wire-Brushing to Remove Rust Scale and Loose Rust.

AT RIGHT: Applying Rust-Oleum Gray (One of Many Rust-Oleum Colors for Rust Prevention and Decorative Beauty).

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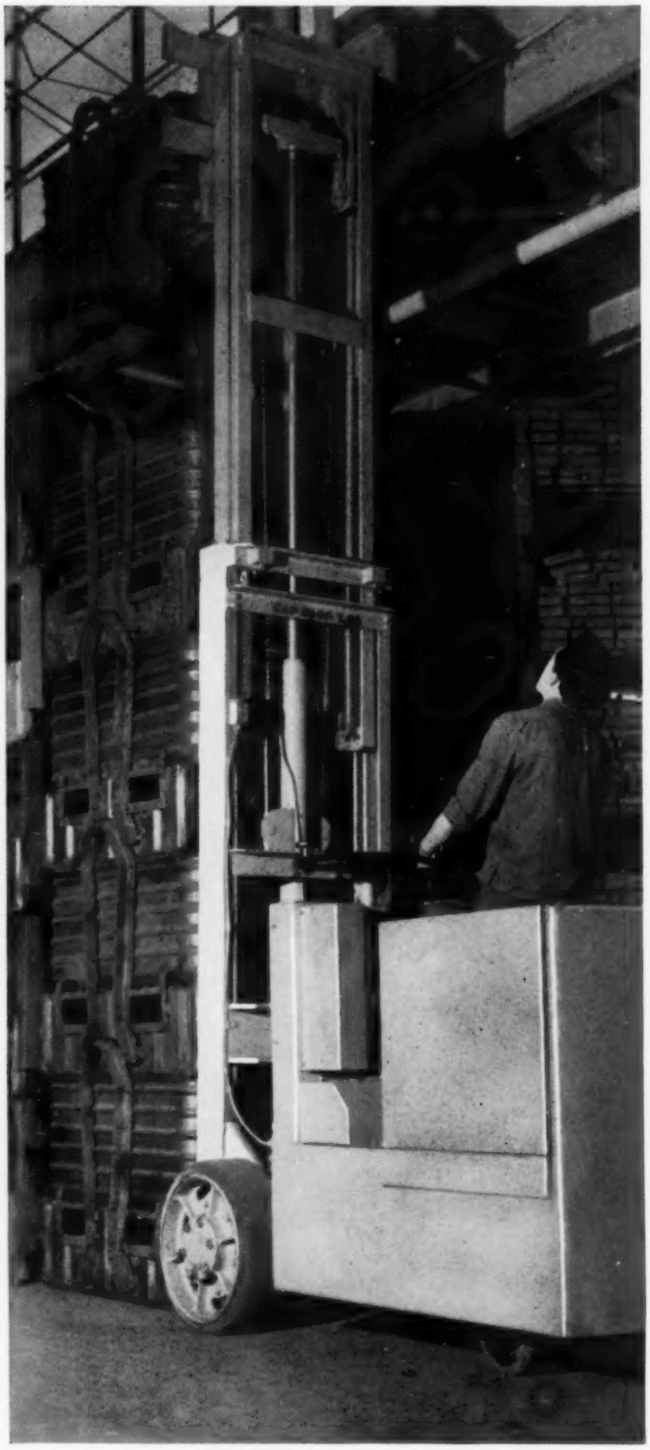

ACCURATE STACKING, precise spotting, are essential for fast, safe materials handling. Exide-Ironclad Batteries respond instantly to any power need required for rapid, accurate handling operations. They enable trucks to handle as much load in the last hour of the shift as during the first ...with no unscheduled down time. Lower costs for operation, maintenance, and depreciation make Exide-Ironclads the best power buy—AT ANY PRICE.

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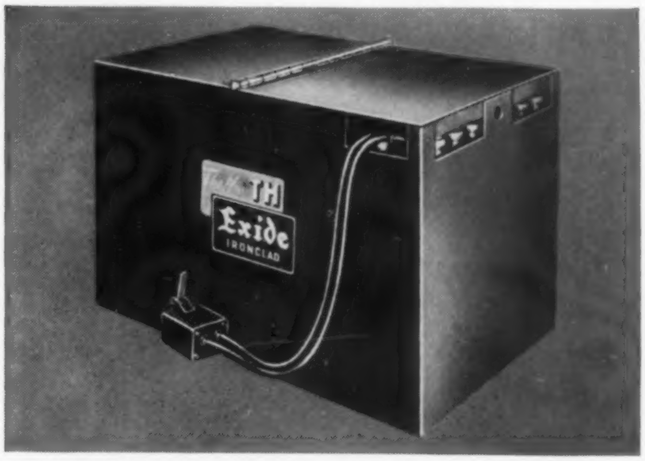

THE NEW THRIFTY HAULER! The improved industrial truck battery. *Non-oxidizing* plastic power tubes assure longest battery life, more capacity in the same space. For full details, call your Exide sales engineer—write for Form 1982 (Installation and Maintenance of Motive Power).

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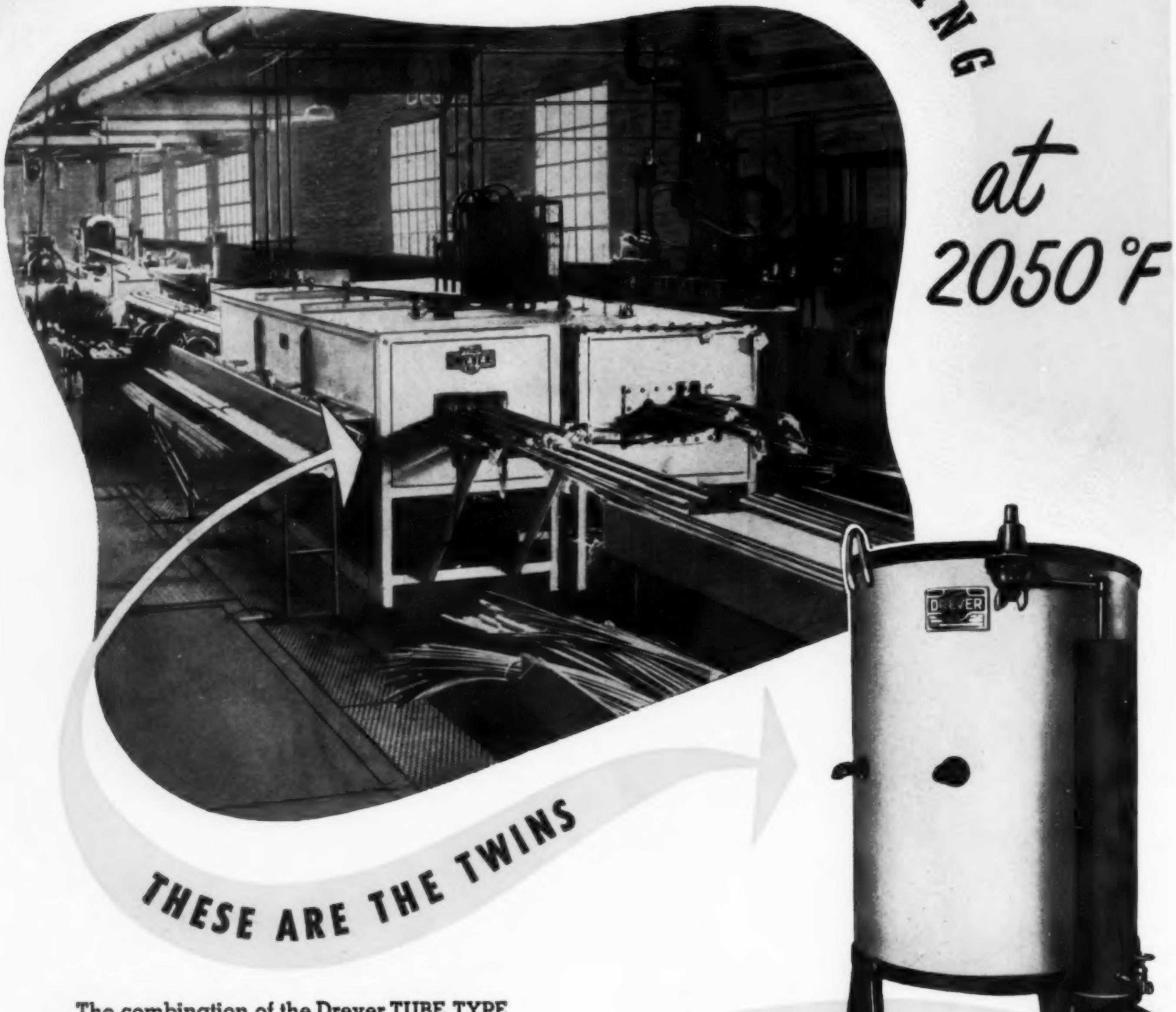

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7—Furnace can be gas or electrically heated
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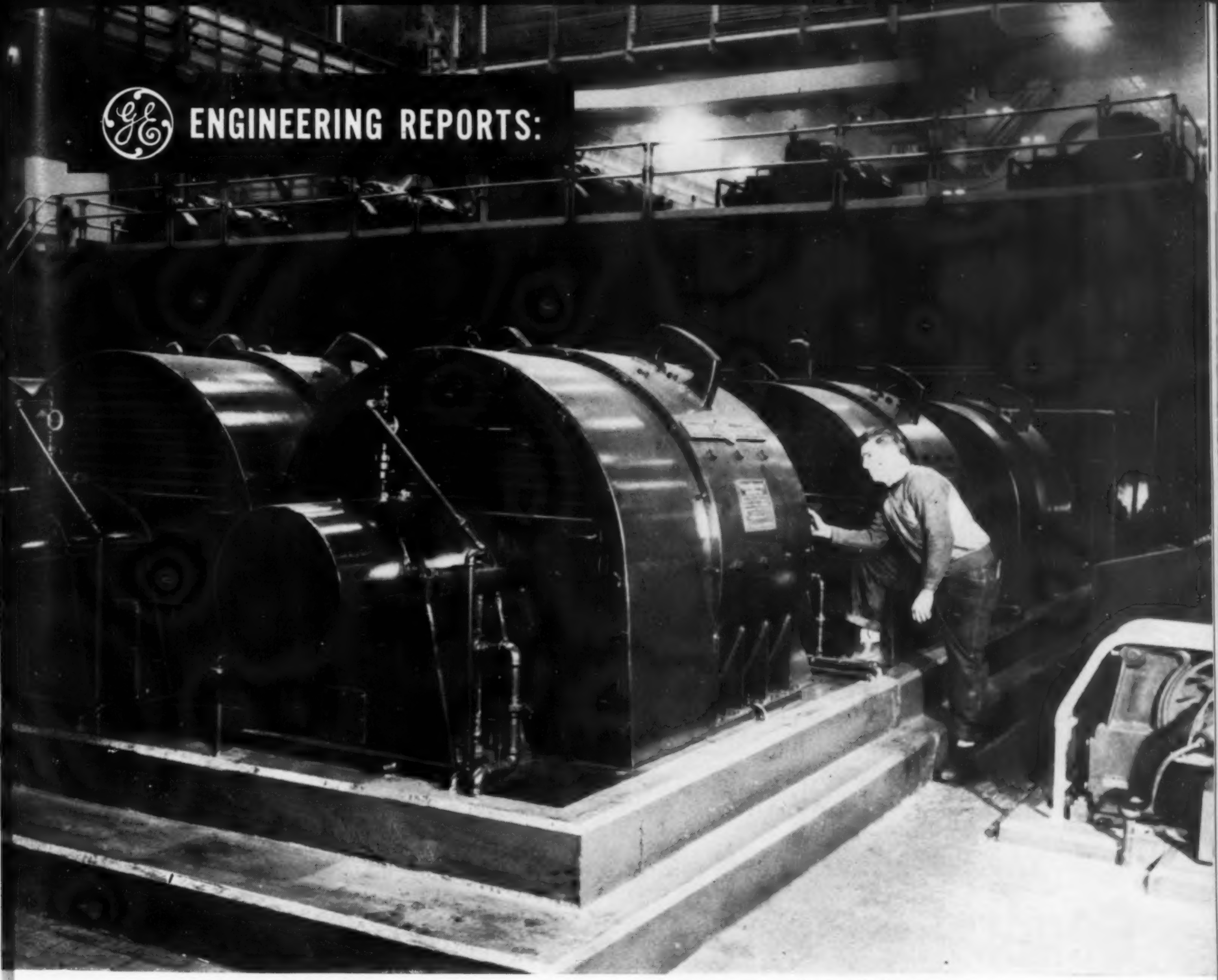
6



RECORD HORSEPOWER. G-E main drive system for world's fastest cold mill at Fairless has record total horsepower of 21,650. This triple-armature twin drive packs 6000 horsepower into No. 5 stand.

Drive-engineered by General Electric . . .

World's fastest cold mill rolls at 7000 fpm

Showcase of the steel industry, the new Fairless Works of United States Steel at Fairless Hills, Pa., reflects the latest in drive engineering and equipment—much of it General Electric. Typical is this 5-stand tandem cold reduction mill, powered by a General Electric drive system.

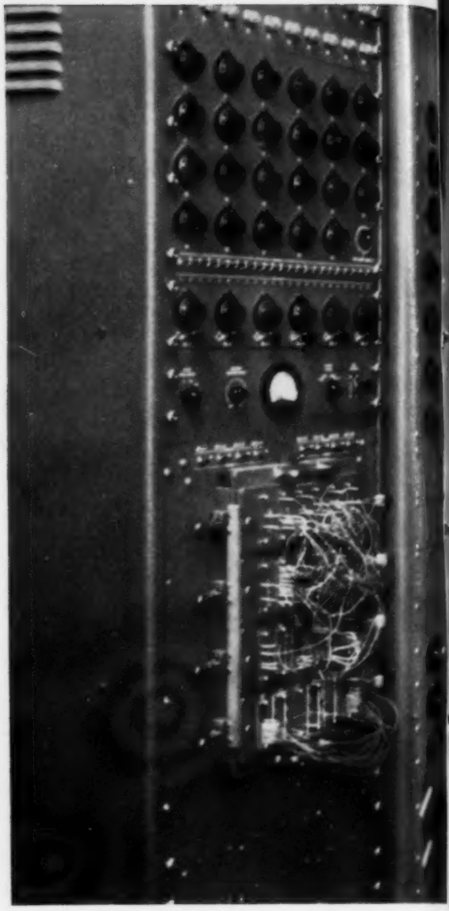
Fastest in the world, this cold mill speeds at 7000 feet per minute—almost 80 miles per hour—delivering two tons of .009-inch-thick strip per minute. Acceleration from standstill to top speed takes only ten seconds. And the combined 21,650 horsepower of its main drives is also a record for this type of mill.

G-E designed individual-generator control gives the mill greater flexibility and simplicity of operation, plus a higher percentage of "on-gage" strip. G-E drive motors, specially designed to reduce stored energy to a minimum, permit acceleration and deceleration at the high rates required. And responsive auxiliary drive system helps assure accurate control of gage and shape of strip even at these high speeds.

See next page for design story ▶

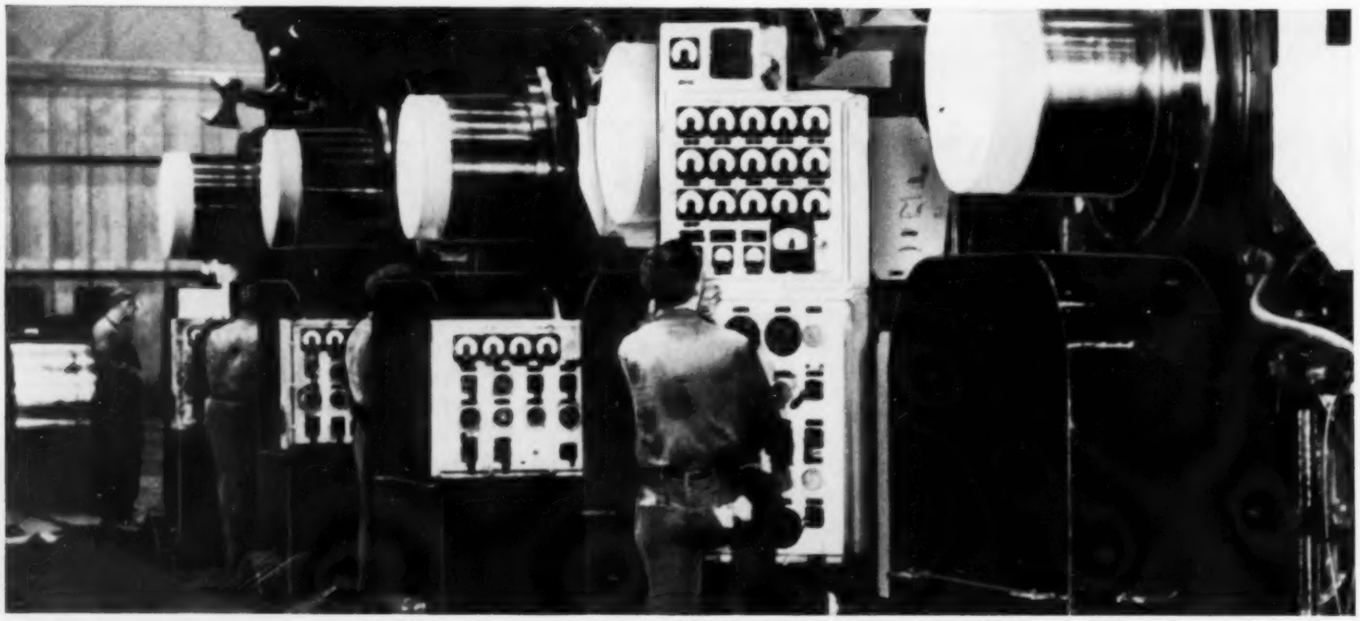
GENERAL ELECTRIC

APPLICATION ENGINEERING—On the job from early planning stages through start-up, G-E Application Engineers like W. E. Miller (left) helped design and install drive system. Here, he discusses 5-stand mill control with U.S. Steel engineers.



At record-breaking Fairless Cold Mill . . .

General Electric engineering services



PRODUCT ENGINEERING—One man has control of 5-stand mill from main control board at No. 2 stand. G-E Product Engineers designed special control equipment which continuously monitors performance, and perceives and corrects variations.

ANALYTICAL ENGINEERING—New circuitry for the 7000-fpm mill was developed using computers such as this electronic differential analyzer being operated by G-E Analytical Engineer F. S. Rothe. Application Engineers C. C. Thomas and R. G. Beadle check results of a "run" of the mill just completed on the analyzer to eliminate problems before installation.

save planning time, speed start-up

FIELD ENGINEERING—Helping with mill's installation and start-up operations, G-E Field Engineers H. L. Peacock (left) and C. E. Batchelder test differential relays with a U.S. Steel engineer.

Key factor in the success of Fairless' cold reduction mill drive was the over-all system approach which co-ordinated the electric and process equipment. U.S. Steel and Mesta engineers, working with G-E engineers as a team, designed the 21,650-hp main drive system.

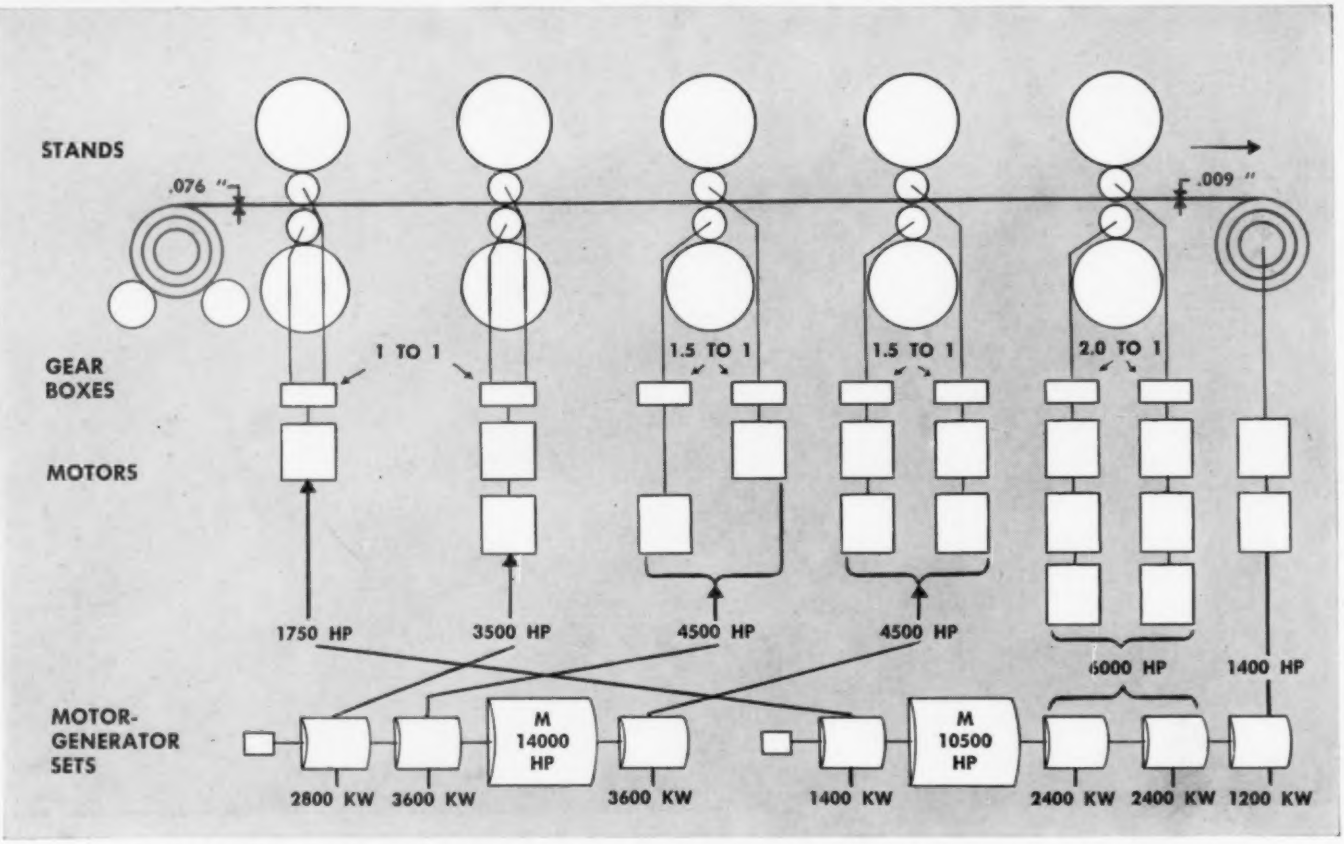
Backing them up were G-E engineers who "ran" the mill on electronic computers to eliminate problems before installation, designed new control and drive circuits, assured the right equipment arrived at the right time, and helped start up the mill.

Whatever *your* steel-mill electrical requirements, these and other G-E engineering services are available to help you achieve higher speeds for greater output, more accurate control of product quality, and lower unit costs to meet today's demands. Your local G-E Apparatus Sales representative will put them at your service. Contact him early in the planning stage. General Electric Company, Schenectady 5, N. Y.

See next page for engineering details ▶

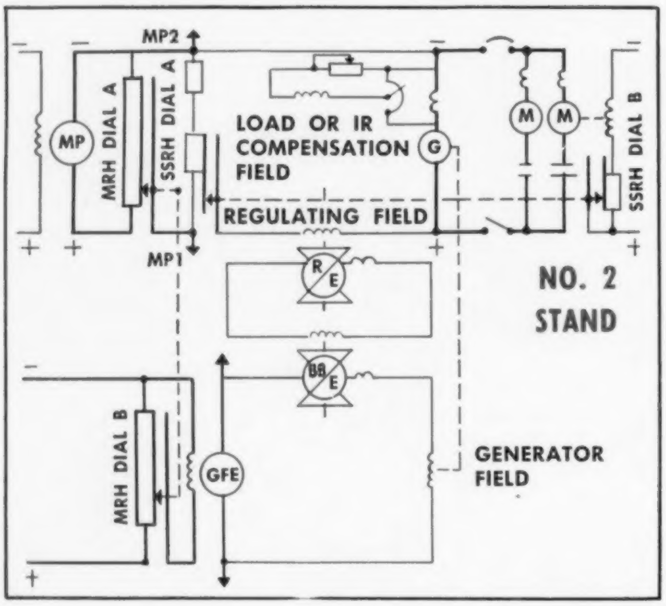
GENERAL ELECTRIC

Another example of G-E drive engineering at work!


STANDS
.076 "
.009 "
GEAR BOXES
1 TO 1
1.5 TO 1
1.5 TO 1
2.0 TO 1
MOTORS
1750 HP
3500 HP
4500 HP
4500 HP
6000 HP
1400 HP
MOTOR-GENERATOR SETS
M 14000 HP
M 10500 HP
2800 KW
3600 KW
3600 KW
1400 KW
2400 KW
2400 KW
1200 KW

17 MAIN DRIVE G-E MOTORS, RANGING FROM 700 TO 2250-HP, DRIVE 5-STAND TANDEM COLD REDUCTION MILL

G-E individual-generator control helps keep strip "on-gage" at Fairless Mill


MP2
MP
MRH DIAL A
SSRH DIAL A
LOAD OR IR COMPENSATION FIELD
G
M
M
SSRH DIAL B
REGULATING FIELD
MP1
R E
NO. 2 STAND
BB E
MRH DIAL B
GFE
GENERATOR FIELD

How G-E individual-generator control works

In control circuit of No. 2 stand (left), mill master rheostat MRH determines voltage on master voltage control bus MP1 and MP2, which is the standard by which each generator's voltage is controlled. By raising or lowering voltage on this bus, voltage of all generators may be raised or lowered in proportion. Mill master rheostat also controls excitation on generator-field exciter GFE, which supplies all stand generators. In this way, regulating amplidynes RE and BBE on each stand can operate at low voltage levels ideal for fast regulator action.

Individual voltage adjustment on each generator is determined by stand master rheostat SSRH. Each stand-motor's speed is also controlled by adjustment of its shunt-field current by this same rheostat.

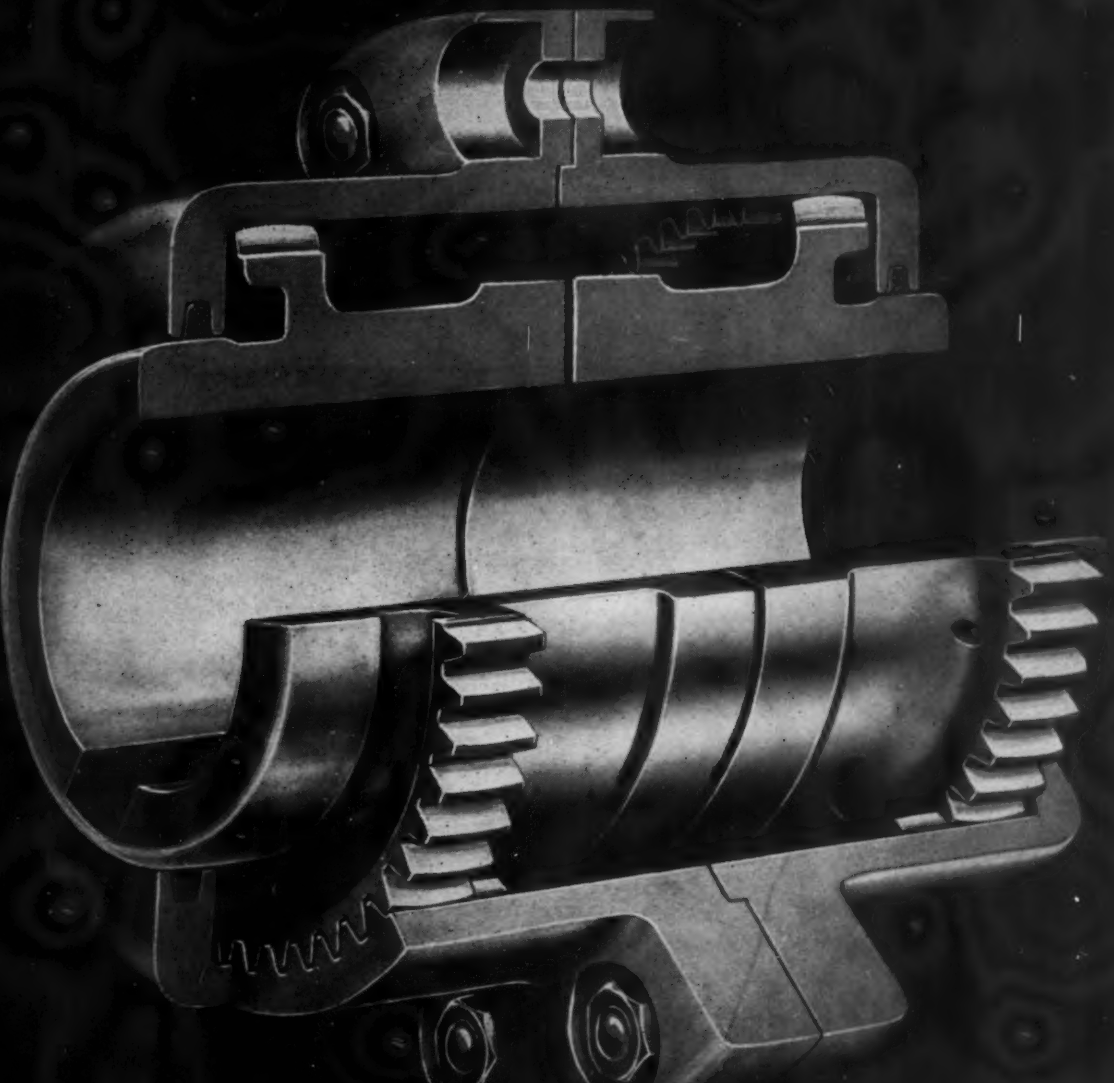
Load, or ohmic-drop compensation, is provided in the regulating system to insure the maximum amount of "on-gage" strip during acceleration, running, and deceleration of the mill.

To accelerate the mill to threading speed, then to running speed, and then back to threading speed, operator need only press respective buttons on conveniently located control cabinet. A full complement of indicating instruments is provided for operator to check speed, load, tension between stands, winding-reel tension, and gage during rolling operation.

659-102

GENERAL ELECTRIC

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.

Ohio Rolls

SHAPING METAL FOR ALL INDUSTRY

choose from 11 types of Ohio Iron & Steel Rolls:

Carbon Steel Rolls • Ohioloy Rolls • Ohioloy "K" Rolls • Holl-O-Cast Rolls • Chilled Iron Rolls • Denso Iron Rolls • Nickel Grain Rolls • Special Iron Rolls • Nioloy Rolls • Flintuff Rolls • Ohio Double-Pour Rolls

THE OHIO STEEL FOUNDRY CO.

LIMA, OHIO • PLANTS AT LIMA AND SPRINGFIELD, OHIO

Industry News...

WHEELING STEEL CORP. TO CONSTRUCT SECOND CONTINUOUS GALVANIZING LINE AT MARTINS FERRY

▲ A second continuous galvanizing line for the production of galvanized sheets and strip will be constructed by Wheeling Steel Corp. This line, to be built at an estimated cost of $4,000,000, will be located at the company's factory in Martins Ferry, Ohio, where, in November, 1953, the first such line was put into production. The new installation is expected to be in operation by May, 1955.

The line will be capable of producing twice the tonnage of SofTite sheets and strip as the first line and, taken together, the two will supply the trade with all types of coatings, in all gages from 10 to 30, inclusive, in widths up to and including 48-in., and either in cut lengths or in galvanized coils.

The production of SofTite is an exclusive Wheeling process, covered thoroughly by United States patents, and by patents in Canada, England, France, Belgium, and West Germany.

One of the unique features of this new coating process is that electric induction heating is employed in the heating of the coating metal. By far the largest electric induction heated pot for heating zinc metal yet built in the world is used in the new coating process. The metal coating bath will hold 175 tons of zinc metal, and will be heated by electric induction heating units which use approximately 2,300,000 watts of electric power at all times, more than enough electricity to supply an average small city with all its requirements.

The new continuous line will operate at speeds of 50 to 200 ft per minute and, at maximum production, the line will produce as much as 50 tons of coated material per hour, or almost three times the production of any such line now in operation.

TO REVAMP 28-IN. MILL FOR BEAM PRODUCTION

▲ Facilities to produce wide-flange structural steel beams at its Indiana Harbor Works, are planned by Inland Steel Co.

The Inland project contemplates the revamping of the 28-in. mill on which standard structural shapes and railroad rails are now rolled. It will be converted so as to roll the wide-flange beams in addition to its present products.

Only two other companies in the United States produce a full size range of this type of beam and only one mill for their production is now located in the Chicago area, the company said.

The company did not disclose an estimate of cost for the project which, it said, would involve additions to existing buildings and relocation of some present facilities besides the installation of some new machinery and equipment.

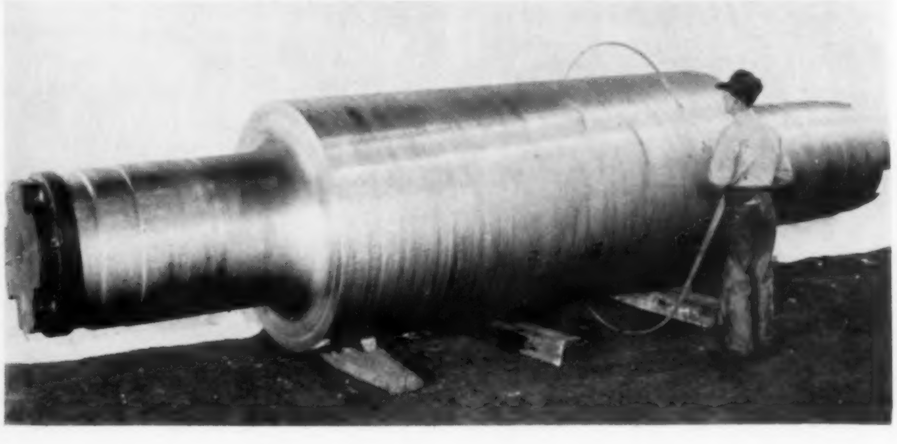
It is expected that work will start immediately and can be completed within 18 months.

The mill will have capacity to produce up to 325,000 tons of 8-in. to 24-in. wide-flange beams annually, depending on the tonnage of other products rolled.

The wide-flange beam was said to be in increasing demand because of its advantages for wide-span structures without intermediate supports, such as modern one-story factories and store buildings and in highway bridges and overpasses. It is widely used in skyscraper construction.

MAMMOTH BACKUP ROLL BUILT BY CONTINENTAL

This giant backup roll was manufactured, machined and annealed by Continental Foundry & Machine Co. at its Wheeling, W. Va., plant, for use in a four-high rolling mill. It measures 60 in. in diameter and weighs 147,000 lb. In the rough, the roll weighed close to 185,000 lb.



AGREE ON EXCHANGE OF SILICON STRIP DATA

▲ Arrangements have been concluded between Allegheny Ludlum Steel Corp. and Mannesmann-Huttenwerke A. G., a leading steel company in West Germany, for the exchange of technical information concerning techniques and processes for the manufacture of grain oriented silicon strip steel, a highly efficient electrical material.

Under terms of the agreement, the German company is receiving information on techniques and processes for the manufacture of the material in possession of Allegheny Ludlum. In return, the German firm has made a substantial cash down payment and has agreed to pay a royalty on all the material it produces over a period of approximately 10 years. It also will give Allegheny Ludlum free rights to any improvements which it may make in the material or its manufacture during the life of the agreement.

Four technicians from the German

NOW you can stock
ONE CHECK VALVE
for any and all requirements

This DURABLA check valve unit, added to any standard fitting (such as the reducing coupling shown above) gives you a complete check valve *suitable for ANY service.* With a few of these units in stock you are prepared for any emergency.

Because DURABLA check valves will operate in any position, they can be installed without changing existing lines. Made of stainless steel (or a combination of stainless steel and ni-resist), they will handle practically any liquid, gas or air—at all temperatures and pressures.

DURABLA check valves are available in seven standard line sizes, from ⅜" to 2". Ask your distributor for complete information or write us direct.

DM-1

DURABLA

DURABLA MANUFACTURING COMPANY
114 LIBERTY STREET • NEW YORK 6, N. Y.

company have recently been in this country for a training period preparatory to establishing production facilities in a Mannesmann plant, possibly at Duisburg-Huckingen, West Germany. The training of the technicians was done at the company plants in Brackenridge and West Leechburg, Pa.

J&L RESEARCH CENTER UNDER CONSTRUCTION

▲ Jones & Laughlin Steel Corp. has begun construction on a new research center in Pittsburgh, Pa. The laboratory, to be completed in mid-1955, will be located 400 feet above the Monongahela River, overlooking J&L's Pittsburgh Works.

The new research center, to cost initially more than $1,500,000, will consist of several buildings, housing a research staff of about 100. The tract of land where the research center will be located is part of a larger area, which J&L has owned since 1921.

The laboratory site is only 15 minutes by auto from downtown Pittsburgh. Its nearness to the Pittsburgh and Aliquippa Works will make possible continued close cooperation between the research staff and production personnel.

The more theoretical aspects of J&L's research will be moved into the new location. Research at most of the existing locations will be continued—metallurgical research at the Pittsburgh Works research laboratory, coal and coke research at Aliquippa Works, and ore research at Negaunee, Mich.

TATA AWARDS CONTRACT TO PITTSBURGH FIRM

▲ Completion of contractual arrangements with Tata Iron and Steel Co., Ltd., covering supervision and erection of extensive new steelmaking facilities for the Indian organization, has been announced by Swindell-Dressler Corp.

The project comprises five open hearth furnaces complete with all auxiliaries, stock house, mold yard, stripper, three Bessemer converters, two hot metal mixers, and all required buildings, track, piping and electrical work.

It is stated by William H. Cosgrove, president of Swindell-Dressler, that while much of the required equipment is to be procured from English and West German sources, Indian materials and labor will be used to the maximum extent. Tata Iron and Steel is a privately-owned industry, and the new project is privately financed, with no American or Indian government money in the picture.

Site of the expansion program is Tata's plant at Jamshedpur, in the province of Bihar, approximately 100 miles west of Calcutta. Originated in 1911, the company's steel-making and finishing operations are among the largest in the East.

Work is scheduled to begin on the project in mid-September of this year, with completion expected late in 1957.

TO INSTALL ANNEALING UNITS AT McLOUTH STEEL

▲ A $1,000,000 contract has been awarded to Lee Wilson Engineering Co., Inc., by the McLouth Steel Corp.

The order covers the installation of all the annealing equipment for McLouth's new cold strip mill at Trenton, Mich.

The 24 single-stack furnaces, together with 60 bases, comprise the largest single-stack annealing installation up to the present time. It will give McLouth an annealing capacity of 40,000 tons per month of low carbon strip steel in widths up to 52-in.

A unique feature of the installation is an oil firing system that uses a lightweight oil. A special burner design enables the oil to be burned with the same characteristics as gaseous fuels. This is accomplished by the use of recuperators which utilize the waste heat from the radiant tubes to preheat the combustion air.

It is estimated that the installation will be completed in approximately eight months.

BLAW-KNOX DIVISION COMPLETES EXPANSION

▲ Blaw-Knox Co. celebrated the opening of the newly-expanded facilities of its Power Piping & Sprinkler Division amidst predictions of further growth in this field.

Begun more than a year ago, the project involved the addition of two

Quick-As-Wink®

HYDRAULIC VALVES

IN
OUT
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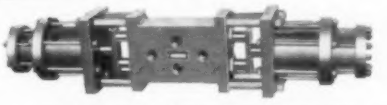
OUT

Hand Lever and Pilot Cylinder Types—pressures to 5000 psi.

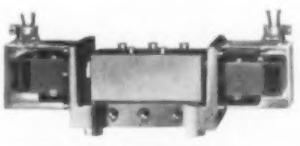
Have won industry wide recognition for unsurpassed dependability

● Positive and fast acting, Quick-As-Wink Control Valves are designed and built to meet the most exacting requirements. Bodies of hydraulic valves are either forged or milled from solid bars. The hollow, radially ported, stainless steel plungers are chrome plated and polished to minimize wear. All parts are readily accessible and maintenance—that consists mostly of the very occasional replacement of the packing — can be done easily **in the field** without even disconnecting the piping. This avoids the necessity of returning valves to the factory for servicing or maintaining large standby inventories. Let us recommend the sizes and types that will meet your requirements best. Write for Bulletin 531. It gives full details.

Ask us also about . . .



DOUBLE PILOT CYLINDER HYDRAULIC VALVES operated with air or hydraulic pilot cylinders—3 position; neutral, compound-on or compound-exhaust.



DOUBLE SOLENOID "O-TYPE" VALVES for pressures up to 125 psi. Widely used as pilot valves and for operating air cylinders.

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1925 East Pershing St., Salem, Ohio for cutting cost corners . . .

NORTHERN CRANES

The present necessity of cutting costs and increasing production requires the most effective use of tooling and equipment. Maintaining your competitive position may be resolved by your ability to cut every possible cost corner in your processing.

A NORTHERN CRANE—in capacities up to 150 tons, and of any desired span — provides safer, faster, more dependable heavy load handling than was adequate when production schedules were lower, or when the high cost of delays was not as critical as today. You can cut many cost corners with NORTHERN CRANES.

*Bulletin SE-108-A (up to 150 tons) or,
Bulletin HL-115-R (up to 20 tons)
will be sent at your request.*

NORTHERN CRANES · HOISTS · TRAVELATORS

NORTHERN ENGINEERING WORKS
210 CHENE ST., DETROIT 7, MICH.

new production bays totaling 13,000 sq ft. One of these bays houses the streamlined facilities for the manufacture of spring hangers and vibration eliminators. The new facilities also provide for expanded machining operations and for better work flow on pipe fabrication contracts.

New office quarters built above the plant addition enable the division for the first time to unite administrative, headquarters sales, clerical, and engineering personnel into a central headquarters.

CRUCIBLE OPENS NEW FACILITIES AT BUFFALO

▲ Crucible Steel Co. of America officially opened its new branch sales office and warehouse building at Buffalo, N. Y., June 24.

The newly-constructed offices and warehouse, at 2051 Elmwood Avenue, occupy an area of 14,200 sq ft with potential expansion space of another 40,000 sq ft.

The warehouse contains the latest facilities for storing and handling materials. These include an overhead crane, nine 24-ft "A" racks, horizontal racks and special equipment for storing tool bits and drill rod.

NEW PLANT TO INITIATE SQUARE D EXPANSION

▲ Acquisition of a 19-acre site in Royal Oak, Mich., a Detroit suburb, has been acquired by the Square D Co. for a new heavy equipment manufacturing plant and regional sales office. It is the first phase of an extensive expansion program.

Initial construction which will provide 60,000 sq ft of floor space is scheduled to begin about August 1, and occupancy is planned for early next year.

REVEALS TREND TOWARD FORCED-OIL COOLED UNITS

▲ A continued trend toward forced-oil cooling for power transformers above 15,000 kva was revealed by the latest market research data of General Electric Co.

Reporting industry trends in the estimated 1953 buying of power transformers, N. E. Dillow, manager of marketing research and product

(*Please turn to page 163*)

Earle Browning, Manager
Steel Mill Engineering

This hot-strip mill needed smoother control and fewer cobbles

Mr. Browning shows you on the next three pages how Westinghouse apparatus and engineering assistance solved these hot-strip problems.

Westinghouse engineers had ideas for ingot buggy, runout table and coiler

When Westinghouse engineers have complete electrical responsibility, they can coordinate drives and regulating systems for the complete mill. You benefit from a boost in production, a smaller scrap pile, a mill that's easy to run.

Remote controlled ingot buggies are a step toward automation. The operator of the ingot crane, above the soaking pits, runs the show. He presses a button, and the buggy slides beneath him and stops. After loading, he presses another button, and the buggy departs to drop its ingot onto the table in front of the mill stands. Meanwhile, the crane finds a new position. The empty buggy will obediently follow it to that spot. Or the operator may ask the buggy to wait.

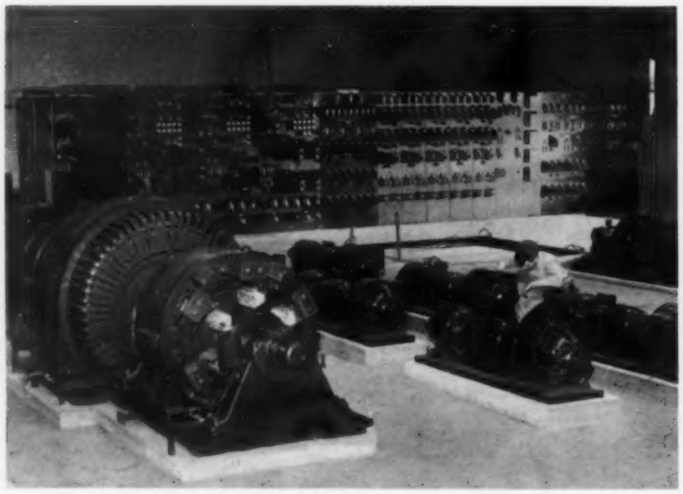
Main elements of this control are two parallel and sectionalized control rails. One is contacted by the cranes in their travel, and the other, with matching sections, provides the buggy control. These two rails form two legs of a Wheatstone's bridge. When the controlling crane and the buggy are in different locations, an unbalanced current flows. This current hurries the buggy along its track until the unbalance disappears.

To handle wide strip ranges needed on high-speed, hot-strip mills, Westinghouse has a full line of drive equipment. D-c motors driving the stands are supplied either with Ignitron rectifiers or d-c generators driven by synchronous motors. Westinghouse Rototrol® provides the precise synchronization between mill, table and coiler drives required when the strip is in both the mill and coiler and after the strip leaves the last stand of the finishing train and races into the coiler located near the mill. Westinghouse engineers carefully match all drive characteristics and coordinate the total system with Rototrol regulators.

Rototrol licks a lot of mill control problems. With runout table rolls and coiler mandrels driven by individual d-c motors, each controlled by adjustable voltage, the load shifts as the strip zips from the mill along the table and to the coiler. Rototrol regulates for the speed changes and inertia effects that cause looping and cobbling. As a result, the speeds of the tables and coilers always bear a definite relationship to the speed of the mill. Simplifies your operation.

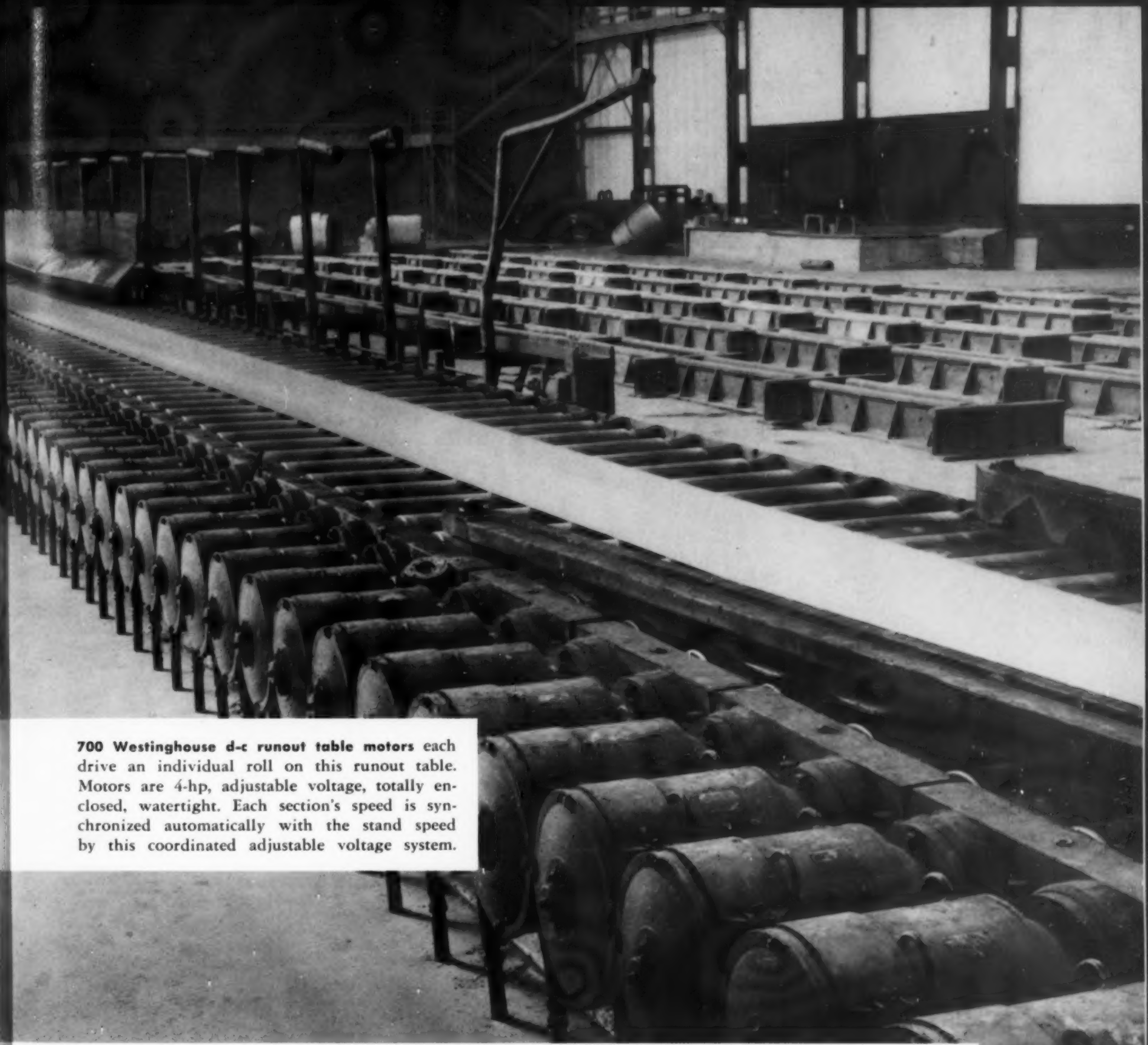
YOU CAN BE **SURE**...IF IT'S

Westinghouse

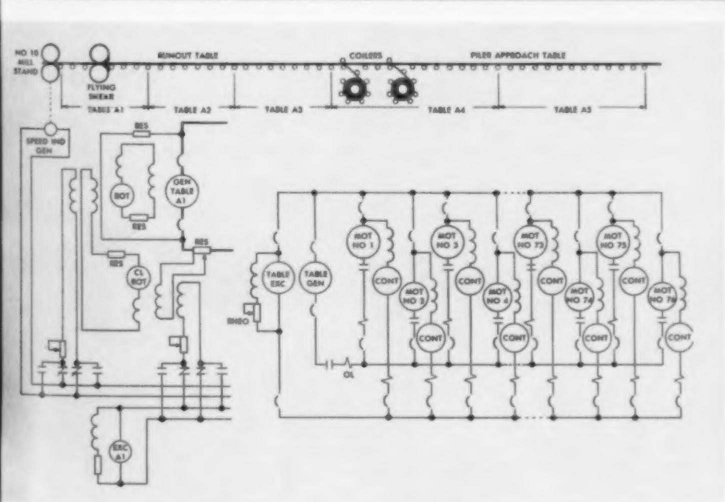


Ingot buggy control is visible at the board's left end. Rototrol regulating sets and the power supply motor generator set are in the foreground. The operator inspects one of five Rototrol m-g sets.

22-panel adjustable voltage control regulates runout tables and coilers. Current-limit Rototrols accelerate or retard the drive. Inset: Type M d-c contactor, a Westinghouse control line component.



700 Westinghouse d-c runout table motors each drive an individual roll on this runout table. Motors are 4-hp, adjustable voltage, totally enclosed, watertight. Each section's speed is synchronized automatically with the stand speed by this coordinated adjustable voltage system.


NO 10 MILL STAND
FLYING SHEAR
RUNOUT TABLE
COILERS
PILER APPROACH TABLE
TABLE A1
TABLE A2
TABLE A3
TABLE A4
TABLE A5
SPEED IND GEN
RES
ROT
RES
GEN TABLE A1
RES
RES
CL ROT
RHEO
TABLE EXC
TABLE GEN
MOT NO 1
CONT
MOT NO 2
CONT
MOT NO 3
CONT
MOT NO 4
CONT
MOT NO 73
CONT
MOT NO 74
CONT
MOT NO 75
CONT
MOT NO 76
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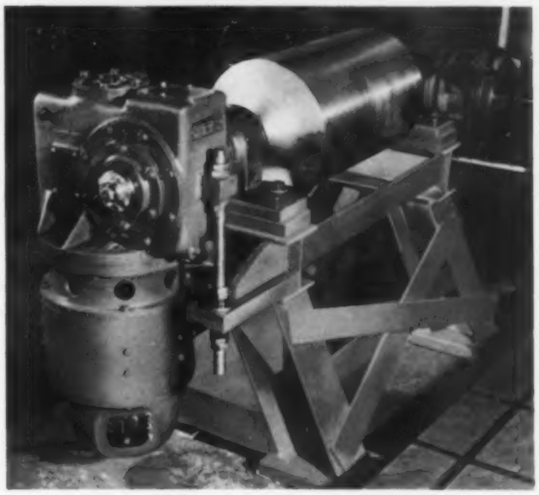
OL
EXC A1

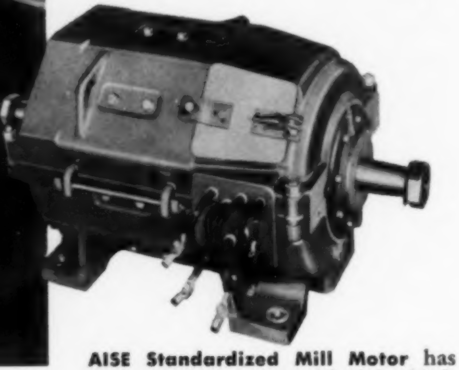
Westinghouse Rototrols match table and coiler speeds to the mill speeds. Each table section and each coiler are supplied power by an individual direct-current induction generator.



New floating-type gearmotor matched to a high-speed motor gives you an economical drive. This unit (right-angle type with worm gearing) floats with the roll. It assures alignment, saves space.

Flying shear is controlled from this desk, located in the pulpit. Both the roll diameter compensating and the cut-to-length potentiometer rheostats are in front of the operator.

New Life-Line® "A" motor has frame, feet and end brackets of heavy cast iron. Other new Westinghouse features: Bondar insulated wire; unitized stator; balanced, die-cast rotor; pre-lubricated bearings.



AISE Standardized Mill Motor has high starting torque—ideal for high inertia loads. Its simplified construction makes servicing and maintenance easy, and it performs efficiently under toughest conditions.

Flying shear and mill speeds are matched by Rototrol

On this new flying shear setup, a speed-indicating generator, mechanically connected to the last finishing mill stand, has its voltage bucked against another speed-indicating generator coupled to the shear drive. Any difference in voltage between these generators actuates the Rototrol-electronic regulator to increase or decrease the shear speed as required. A single motor forms the Westinghouse flying shear drive. It's located in the motor room—a cleaner, less cramped area. The shear is accelerated to speed in approximately three-quarters of a second. It stops just as quickly. An operation like this cuts scrap losses.

Westinghouse maintenance service will keep this rugged apparatus at peak performance. Westinghouse has 31 Renewal Parts Warehouses, 38 Repair Plants, and 56 Field Service Offices. Put our facilities to work for you. Phone your nearby Westinghouse representative. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania.

MP-3017

YOU CAN BE *SURE*...IF IT'S Westinghouse

Perry Croco, Engineering Manager in the Westinghouse Pittsburgh office, backs up the salesmen in his territory with first-class steel engineering help. Put him—or his counterpart in your area—to work for you. Ask your Westinghouse representative for these booklets: **Rototrol in the Steel Industry (B-3998-B), Westinghouse Gearmotor (B-5645), Complete Industrial Control (B-6051), New Life-Line "A" Motor (B-6154), Magamp in the Steel Industry (B-5468), Mill Motors and Controls (B-4730)** or write to: Industrial Products Advertising, Westinghouse Electric Corp., Box 868, 3 Gateway Center, Pittsburgh 30, Pa.

MP-3017

(Continued from page 158)

planning for the company's Power Transformer Department, pointed out that 50 per cent of the kva in single phase units and 63.7 per cent of the kva in three phase units ordered during 1953 were forced-oil cooled. In 1945, there was practically no activity in this type of cooling and self-cooled units prevailed, according to company statistics. Only approximately three per cent of the kva was in self-cooled units in 1953.

Another continued trend was the preference for three phase units instead of single phase banks. In 1953 the electric utility industry purchased 83 per cent of the three-phase transformation banks in the form of three-phase transformers. Only 17 per cent of the banks were made up of three single phase units.

Acceptance of reduced insulation was another 1953 trend. Units rated 230 and 330 kv were all ordered with reduced insulation, while 77 per cent of the units for 138 kv were ordered with reduced insulation.

The company's power transformer department reported that 44 per cent of the orders received for units rated 501 kva to 10,000 kva were for its repetitive manufacture transformers, indicating an increasing acceptance of standardized units in the industry.

FOXBORO WILL OPEN NEW PITTSBURGH PLANT

▲ A new 15,000 sq ft plant being constructed at Pittsburgh, Pa., by the Foxboro Co. is scheduled for completion by August 1. The new factory, will double the present instrument assembly, service and repair facilities, keeping pace with increased demands for instrumentation throughout industrial Pa., W. Va., Ky., and Ohio.

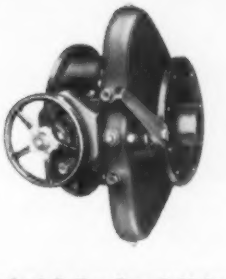
It is the second of three to be erected this year as part of Foxboro's expansion program. A new plant in Dallas, Tex., was opened in April and another in San Leandro, Calif., will be ready for occupancy by August 15.

Foxboro has maintained Pittsburgh sales offices and repair facilities since 1918 and has occupied its own shop since 1941. Mr. A. H. Shafer, who joined the company in 1921, continues in charge as district manager.

A SURE SIGN OF SAFETY
GOGGLE PLATES FREE INSTANTLY!
Bailey
GOGGLE VALVES

For shutting off gas mains from 6" to 72" in diameter, these valves are the means to complete safety, complete dependability.

Whether they are used every day or as infrequently as once a year, they open or close instantly. A tight, sure seal is provided by a clamping force applied equally at all points around the disc periphery. The same powerful mechanism frees the goggle plate.



If desired, Bailey Goggle Valves may be totally enclosed. Both types—open and enclosed—require only a minimum of maintenance.

WILLIAM M. Bailey COMPANY
ENGINEERS
LEADERSHIP THROUGH QUALITY
1221 BANKSVILLE ROAD PITTSBURGH 16, PA.

W. PARKE JOHNSON

"Both management

and labor approve the

Payroll Savings Plan..."

MEYER KESTNBAUM
President
Hart Schaffner & Marx

"Both management and labor approve the Payroll Savings Plan for the purchase of United States Savings Bonds because it enables loyal American workers to help themselves and their country at the same time. A strong backlog of savings is a stabilizing factor in the economy. It is also an element of comfort and security for the individual because it helps him plan a sound future built on sound money. We at Hart Schaffner & Marx take pride in the fact that we introduced the Payroll Savings Plan in 1940 and that it has been continually in operation since that time."

As president of a company which was among the first to offer its employees an opportunity to build for their future through the systematic investment in U.S. Savings Bonds, Mr. Kestnbaum is well qualified to evaluate the benefits of the Payroll Savings Plan:

- "*A strong backlog of savings*": The *cash* value of Series E and H U.S. Savings Bonds held by *individuals* at the end of March, 1954 amounted to $37,175,000,000.
- "*a stabilizing factor in the economy*": The month-after-month investment of millions of dollars in Savings Bonds by more than 8,000,000 enrolled Payroll Savers constitutes probably our strongest check on inflation.
- "*a sound future built on sound money*": During 1953, sales of Series E and H Savings Bonds—22% higher than in 1952—provided cash for all maturities and redemptions of those series and still left more than $210,000,000, *net*.
- "*Both management and labor approve the Payroll Savings Plan*": In company after company, management and labor have joined in a planned effort to put a Payroll Savings application blank in the hands of every employee. These simple, person-to-person canvasses have built employee participation in many companies to 90%, 95% and even higher.

If employee participation in *your* Payroll Savings Plan is less than 50%—or if your company does not have a Payroll Savings Plan—get in touch with Savings Bond Division, U. S. Treasury Department, Washington, D. C. Learn how easy it is to help your country, your employees, and your company—through the Payroll Savings Plan.

The United States Government does not pay for this advertising. The Treasury Department thanks, for their patriotic donation, the Advertising Council and

IRON AND STEEL ENGINEER

STRIP MILL CRANES . . . *by "Shaw-Box"*

Many "Shaw-Box" Cranes are in use in strip mills for this type of crane has long been a specialty in the "Shaw-Box" Line of steel mill cranes.

In "Shaw-Box" strip mill cranes — whether built to an individual mill's or to A.I.S.E. specifications — you get the added advantages that come from "Shaw-Box" engineering, fine workmanship, and precision manufacturing methods. These added advantages insure crane performance that make "Shaw-Box" Cranes, for the work they do, the least expensive cranes to buy and use.

SEND ALL YOUR INQUIRIES FOR CRANES AND SOAKING PIT CARRIAGES TO "SHAW-BOX."

"Shaw-Box" CRANES

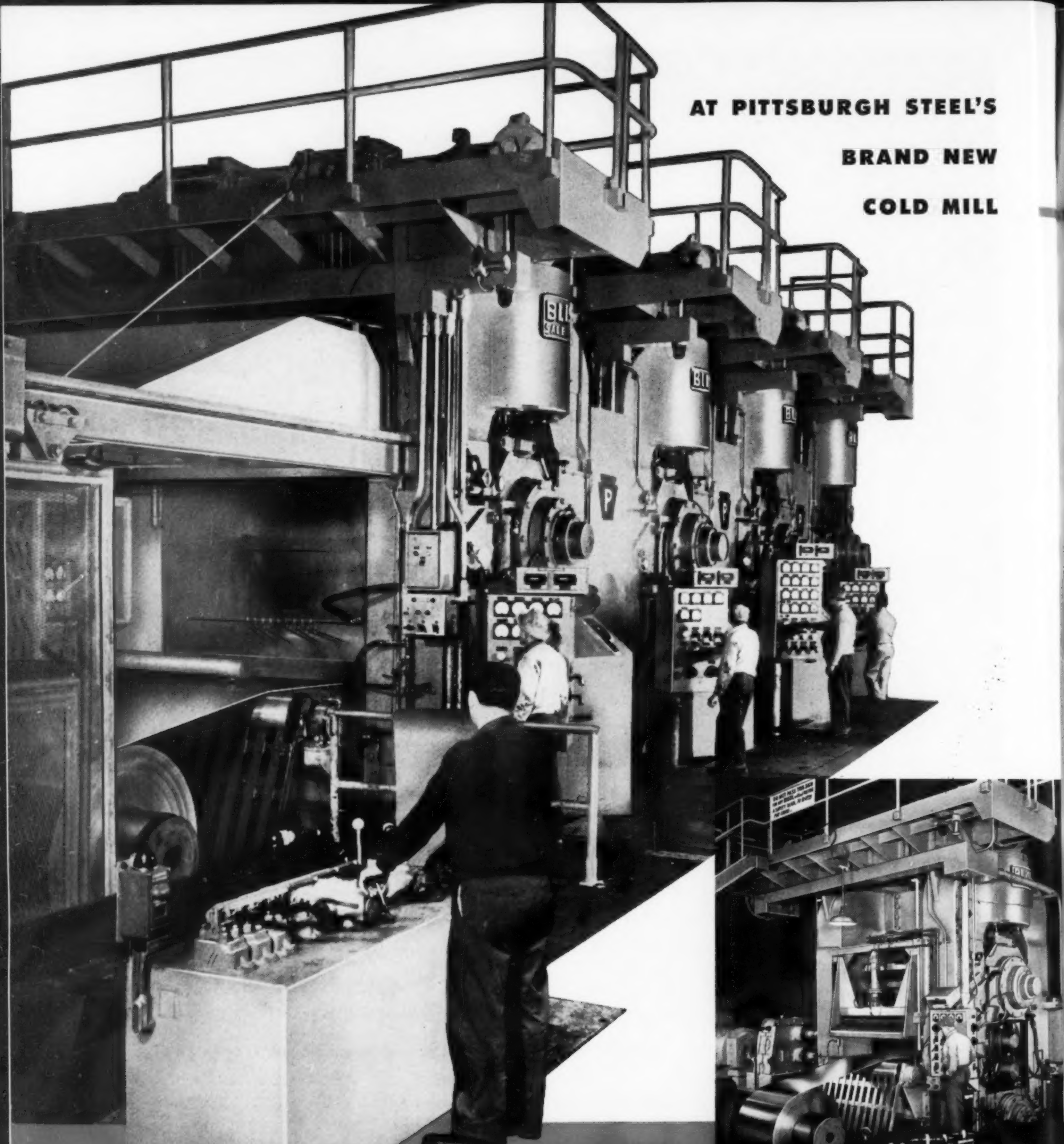
MAXWELL MANNING MM&M & MOORE INC. TRADE MARK

MANNING, MAXWELL & MOORE, INC.

Muskegon, Michigan

Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load-Lifter' Hoists and other lifting specialties. Makers of 'Ashcroft' Gauges, 'Hancock' Valves, 'Consolidated' Safety and Relief Valves, 'American' and 'American-Microsen' Industrial Instruments, and Aircraft Products.

AT PITTSBURGH STEEL'S BRAND NEW COLD MILL



Four-high temper mill (above) and two-high skin pass mill (right).

COLD REDUCING STEEL AT 40 MILES AN HOUR!

Steel strip whips through this Bliss four-stand tandem mill at highway speeds. But more than that, this Bliss mill is especially designed for versatility in production. It will handle a wide range of sizes and gages. Its extra-heavy housings permit the mill to be used for rolling tinplate, also. And the automatic coil loading and unloading machinery, the modern instruments throughout make this fast, versatile mill one of the safest in the industry for the workmen.

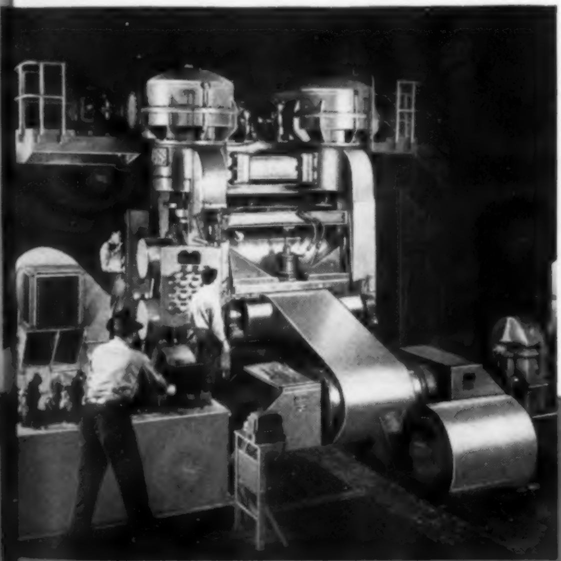
Versatile BLISS Mills meet a variety of cold strip requirements

The giant four-stand 66-in. tandem mill at Pittsburgh Steel's Allenport plant is the "key" to the plant's versatility: it handles widths from 20 to 60 in.; thicknesses from tinplate to 16 gage. What's more, extra heavy housings equip the mill for tougher rolling schedules. The latest in instrumentation is used to control tension, shape and surface finish. Automatic coil handling equipment and safety devices throughout make this mill one of the safest yet designed for industry.

Two similarly-equipped Bliss finishing mills in use at Pittsburgh Steel are equally versatile. A Bliss four-high mill is used for temper passing cold rolled strip; a Bliss two-high mill serves to skin pass hot rolled bands. Both are "combination mills"—designed and built to allow processing of either continuous coils or cut-to-length sheets.

At Pittsburgh Steel, versatility was the "watchword". In other cases, it's specialization. Or speed. But whatever your rolling mill problem, you can count on a "tailor-made" solution from Bliss. You can see for yourself how this approach has helped others—write today for catalog 40-A, our 60-page rolling mill brochure.

Remember: BLISS for Presses, ROLLING MILLS and Special Machinery

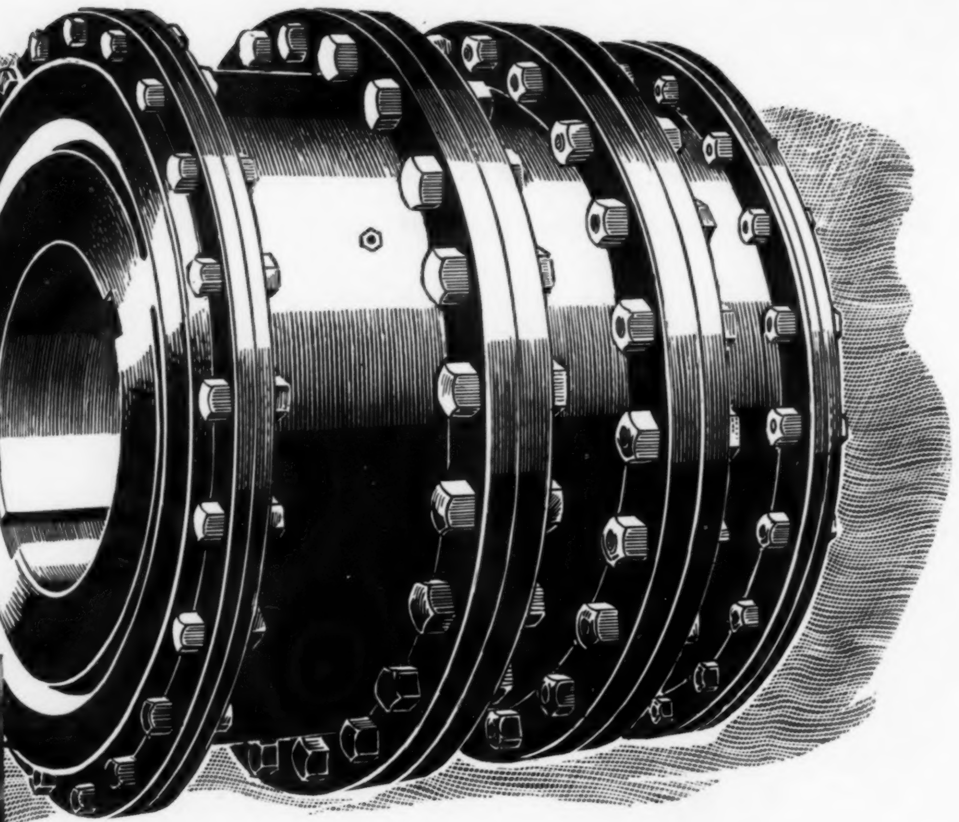


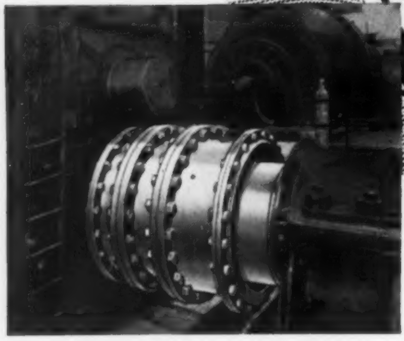
E. W. BLISS Company
General Offices: Canton, Ohio
ROLLING MILL DIVISION, SALEM, OHIO

BLISS
SINCE 1857

ON THE "FINISHING LINE"

In temper passing strip steel, Pittsburgh achieves for its customers the smooth, highly-planished finish and the exact temper required for their end product. Skin passing of the hot rolled strip is done on the Bliss two-high and temper passing of the cold rolled strip, on the Bliss four-high. Each is equipped with the latest instrumentation for gaging the strip, measuring the tension applied and measuring the elongation obtained in each pass. Safety devices are provided throughout for the welfare and protection of the operating personnel.





This 30" Bore Fast's Coupling is on the main drive of the blooming mill at a large Eastern steel mill . . . one of many Fast's linking power to production at this installation.

For SAVINGS up to $30,000 per hour... FAST'S Couplings are FIRST!

A coupling failure in the steel mill installation shown here would cost this mill $30,000 for every hour of down-time! That a Fast's Coupling was selected for this vital spot is striking testimony to the reputation for rugged dependability Fast's Couplings have enjoyed through the years. And Fast's guarantees *you* the same protection against costly shutdowns, whatever your coupling applications!

Remember: Fast's Couplings give you *rugged construction* . . . the original design has been maintained without basic change or sacrifice in size or materials. Fast's Couplings give you *lowest* cost per year . . . *Fast's usually outlast the equipment they connect.* And Fast's Couplings give you the benefit of Koppers *free engineering service* . . . assuring you of the right coupling for any job and the right solutions to tough coupling problems.

For full details on how Fast's Couplings and Koppers Engineering Service can help you insure uninterrupted power transmission, write today for your free copy of our catalog to: KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* 213 Scott Street, Baltimore 3, Md.

KOPPERS ®

THE ORIGINAL

FAST'S Couplings

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Koppers-Elex Electrostatic Precipitators, Aeromaster Fans and Gas Apparatus.

Engineered Products Sold with Service

KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* 217 Scott St., Baltimore 3, Md.

Gentlemen: Send me a Fast's Catalog giving detailed descriptions, engineering drawings, capacity tables and photographs.

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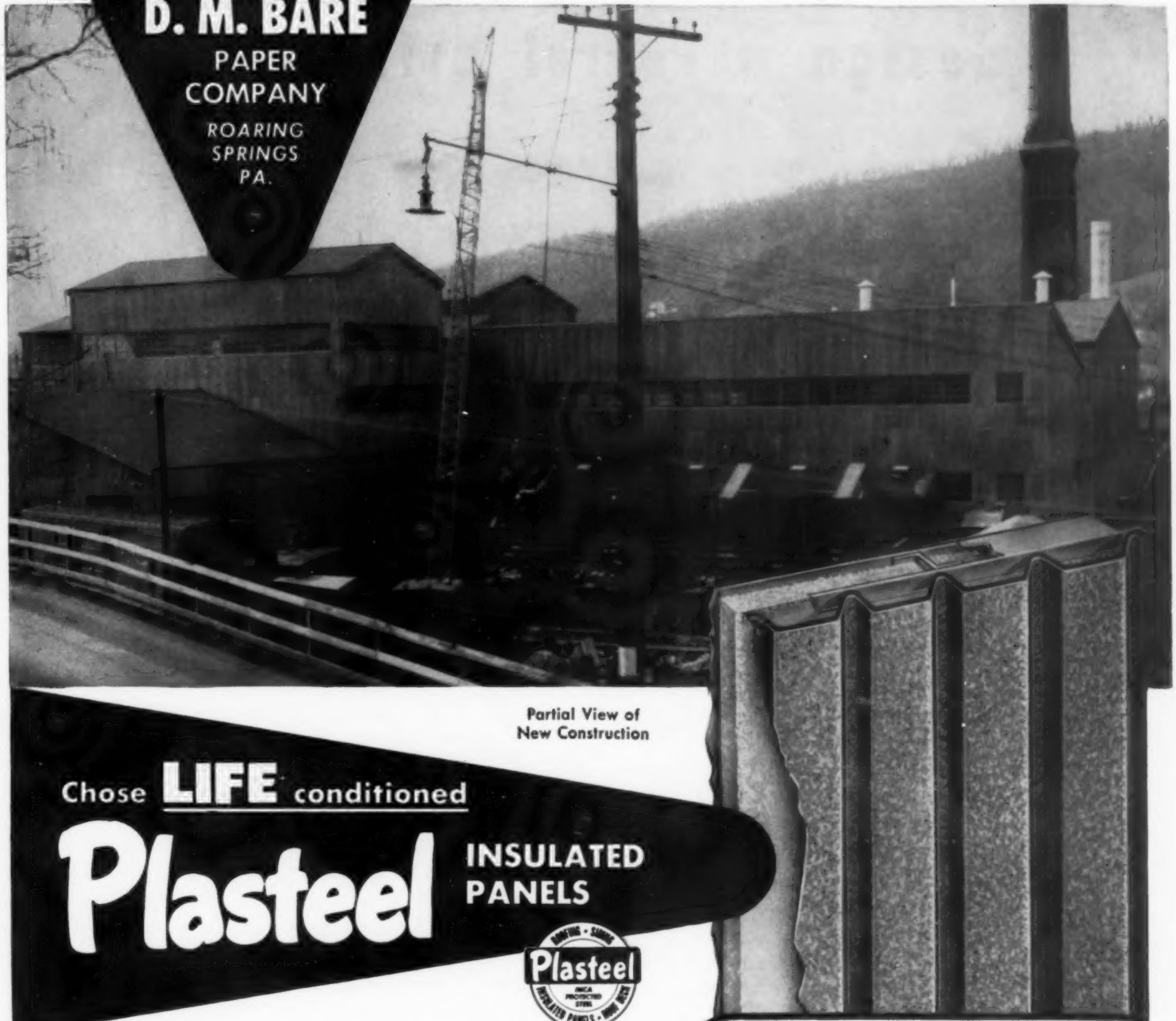

Partial View of
New Construction

Chose **LIFE** conditioned

Plasteel INSULATED PANELS

PLASTEEL Insulated Panels—first choice for another major industrial installation. Here is the answer to long-life, maintenance-free curtain wall construction. PLASTEEL "Mica-Protected Steel" resists corrosive fumes from acids and alkalis. And, because it practically eliminates all metal to metal contact, condensation is minimized and insulation efficiency is increased. PLASTEEL Panels have a "U" factor equivalent to 16" of masonry wall construction—permitting the use of lighter building foundations, less structural steel and more usable floor space. Also, they allow closer control of plant temperatures and humidity levels. PLASTEEL Panels are quickly erected and so flexible in design that alterations or building expansion can be easily handled at minimum cost.

Briefly, these are the advantages of PLASTEEL Insulated Panels. Let one of our sales representatives tell you the complete PLASTEEL story.

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WASHINGTON, PENNSYLVANIA
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★ ROOFING ★ SIDING ★ ROOF DECK

STEEL
BOND COAT
ASPHALTIC PLASTICS
MICA

Tested and classified by Underwriters' Laboratories and Factory Mutual Laboratories.

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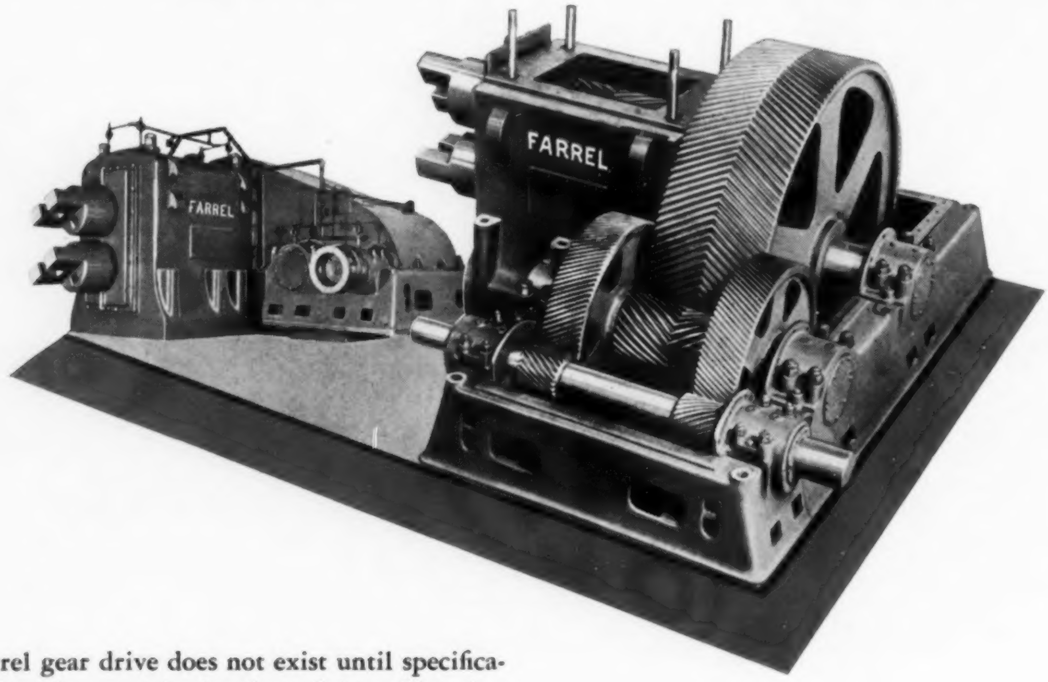
Your SPECIFICATIONS design a Farrel drive



A Farrel gear drive does not exist until specifications have been received and careful consideration given individual requirements.

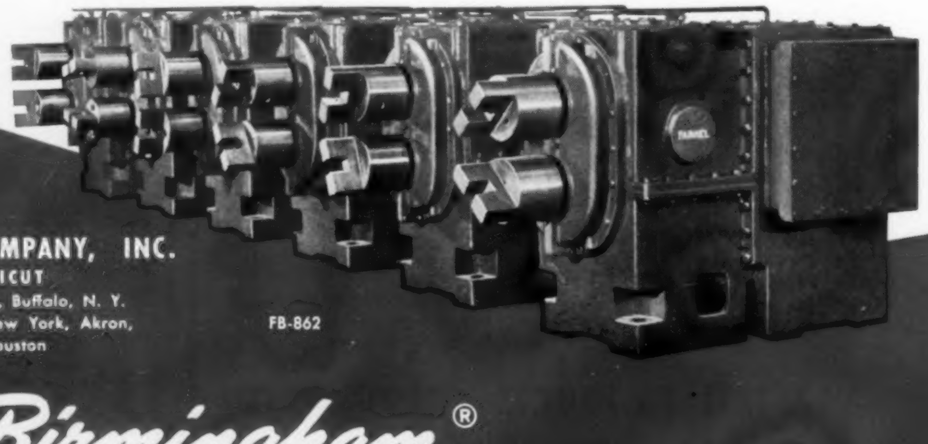
This development of a Farrel unit, whether it is a gear drive, pinion stand or combination, assures optimum efficiency, plus the inherent strength to withstand the shocks, stresses and wear encountered in continuous, heavy duty service.

Illustrated are contrasting examples of Farrel designed-for-the-job mill drives.

Above are two views of a combination reduction unit and pinion stand, transmitting 1250 HP. to a 26-inch two-high mill. The first reduction consists of split (divided) double helical gears. The second reduction gears and mill pinions are Farrel-Sykes continuous-tooth herringbone type, a compact gear arrangement which distributes the load uniformly and requires minimum floor space.

Below is a combination of drive and pinion stands for the first six mills of a ten stand rod tandem. The mills are driven by a motor connected to a herringbone gear reduction unit. Power is transmitted to the pinion stands through bevel gears mounted on a line shaft. Each succeeding pinion stand operates at a higher speed to accommodate the elongation of the rod as it changes form in passing through the mills.

Farrel engineers will be glad to discuss *your* gear drive problems with you at any time.



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Personnel News...

Norman B. Obbard has been appointed president of U. S. Steel's American Bridge Division. He succeeds **Frank K. McDanel** who has retired. Mr. Obbard began with Truscon Steel Co., Youngstown, Ohio, as a draftsman in 1924 and two years later joined American Bridge as an engineer in the tower department. He became assistant to vice president, sales, in 1940. Two years later he was assigned to manage the shipyard division of the Ambridge, Pa., plant during World War II. In 1945 he returned to the Pittsburgh office as assistant to vice president and in 1946 was made vice president and general contracting manager, the position he held until his new appointment.

John W. Price, Jr. was appointed division superintendent, slabbing and plate division of Homestead District Works, U. S. Steel Corp. He succeeds **Robert A. McClure** who has been transferred to the Gary plant of U. S. Steel as assistant general superintendent. Mr. Price began his service with U. S. Steel at the Homestead plant in June, 1937 as an observer in the metallurgical division. He later was placed in charge of the metallurgical laboratory handling development work and became assistant chief metallurgist in July, 1942. In October, 1945 he went to the Pittsburgh offices as bureau manager of railroad material, metallurgical division and in April, 1947 became assistant metallurgical engineer for railroad and commercial forging products. Mr. Price returned to Homestead in December, 1950 as assistant to the general superintendent and in March, 1952 became assistant division superintendent, slabbing and plate division, the position held prior to his new appointment.

Leon H. Nelson has been appointed director of conservation and yield control for Crucible Steel Co. of America. Mr. Nelson's primary responsibility will be to supervise the new Crucible department organized principally to increase yield. The department will function at the company's five plants and will operate out of Pittsburgh headquarters. For the past twenty-one years, Mr. Nelson has been associated with Republic Steel Corp., and served the Chicago district of that company as superintendent of conservation and quality control since 1942. In 1950 he served in Argentina as a visiting consultant on steel mill operations and practices.

Dr. Carl B. Post, chief metallurgist of the Carpenter Steel Co., has been appointed head of the company's metallurgical and research departments. **George V. Luerssen**, vice president in charge of metallurgy has retired after 47 years' service with the company.

Carl W. Kalchthaler was named chief engineer for the Hyatt Bearings Division of General Motors Corp. He succeeds **H. Ralston Gibbons** who has been named technical assistant to the general manager. Mr. Kalchthaler has been with Hyatt since 1925. He was made assistant manager of the Detroit office in 1945. In January, 1953, he came to the Harrison plant as assistant to the general sales manager, the post which he held at the time of his recent promotion.

Clarence J. Klein was elected vice president in charge of engineering of National Steel Corp. He has been vice president—engineering of Weirton Steel Co. since 1952. Mr. Klein has been affiliated with National Steel for 25 years, joining Weirton in 1929 as chief engineer.

Ben C. Wells has been appointed superintendent of the blooming mill at Republic Steel Corp's., Canton, Ohio, plant. Mr. Wells succeeds **Joseph P. Charlton,** who has resigned. **Herman O. Kaiser** has been named assistant superintendent of the blooming mill, succeeding Mr. Wells.

Arthur W. Richards has been appointed chief electrician at the Allenport, Pa., works of Pittsburgh Steel Co., succeeding **Elmer E. Binkney** who has retired. Mr. Richards will be in charge of all electrical department activities at both the new hot and cold sheet mills and the tube division at Allenport. He came to Allenport in 1929 as a wireman, advanced to line foreman in 1941 and to general foreman in 1950. **James L. Dolan, Sr.,** has been appointed assistant chief electrician at Allenport. Mr. Dolan started as a wireman in 1926, moved to motor inspector at the Pilger Mill in 1927, and in 1940 was advanced to turn foreman, a job he has held until his present promotion. **Henry Gallaway** has been promoted to general electrical foreman, sheet division at Allenport. He came with Pittsburgh Steel in 1953, assuming inspection

NORMAN B. OBBARD

JOHN W. PRICE, JR.

LEON H. NELSON

DR. CARL B. POST

responsibilities of the cold mill electrical installations. Since the start of operations at the cold mill, he has served as turn foreman. Prior to joining Pittsburgh Steel he was with Jones & Laughlin Steel Corp. in the electrical department of the hot strip division for 18 years. **Ray Cain** has been appointed general electrical foreman of the tube division at Allenport. Mr. Cain started as a wireman in 1926, transferring to motor inspector at the Pilger Mill in 1927. In 1941, he was promoted to turn foreman, a position he has held until his present advancement.

John L. Young, vice president of engineering, United States Steel Corp., received a Distinguished Alumni Award from Indiana University.

William B. Wallis, president of Pittsburgh Lectromelt Furnace Corp., received a Distinguished Alumnus Award from the Pennsylvania State University.

R. G. Schrock has been elected president of the Euclid Electric & Manufacturing Co. He succeeds **Charles S. Ettenger,** who assumes the position of chairman of the board. At the same time, **C. G. Ettenger** becomes secretary of the company.

R. G. SCHROCK

James B. Austin, Max W. Lightner, and **Robert W. Holman** have been appointed assistant vice presidents of the Research and Technology division, U. S. Steel Corp. Dr. Austin, whose responsibility covers basic researches in the physical and chemical sciences associated with U. S. Steel's technological problems will continue to be located for the time being at the Kearny, N. J., laboratory. Mr. Lightner, responsible for the research activities directly relating to the development of new or improved products and processes, will continue in Pittsburgh near which U. S. Steel's new Research Center is approaching completion. Mr. Holman will be responsible for the research effort relating to the automatic control and instrumentation of manufacturing processes. His entire career in the steel industry has been spent at the Gary Sheet and Tin Mill of U. S. Steel, where he started in 1929. He advanced through various supervisory capacities and was appointed assistant general superintendent of Gary Sheet and Tin Mill in 1952, the position he has held until his present appointment.

Fred Schuchman was named assistant general sales manager for all divisions of the Homestead Valve Manufacturing Co.

Lee H. Coleman, head of the steel and ceramics section of the market development department of Leeds & Northrup Co., has transferred from the company's Chicago office to the Philadelphia headquarters.

LEE H. COLEMAN

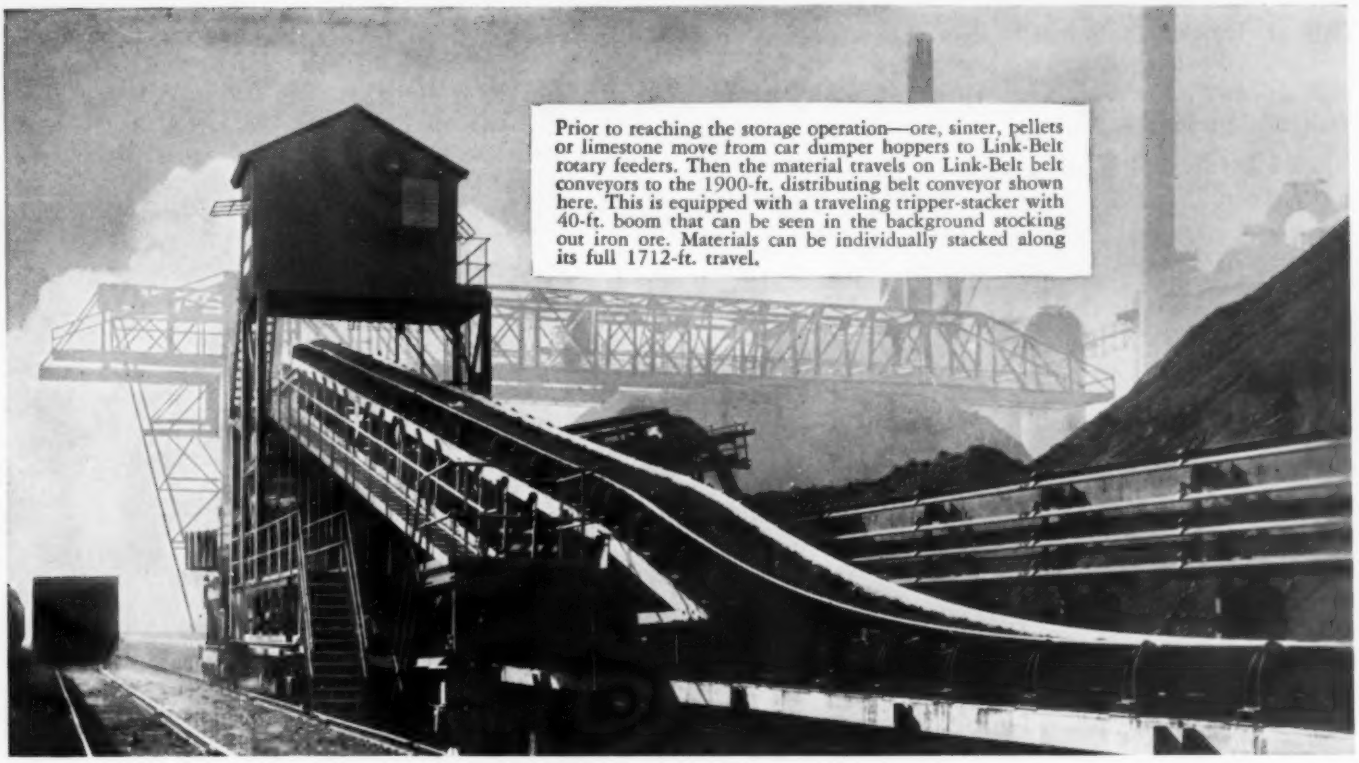
Dr. James A. Crookston has been appointed administrative assistant to the director of research of Harbison-Walker Refractories Co. He formerly was laboratory manager of the company's Hays Laboratory.

Allen F. Brewer, technologist for the Texas Co. has retired after 35 years service with that company. He has served as editor of the Texas Co. magazine *Lubrication* for 32 years.

William C. Bennett was appointed electrical engineer of Alliance Machine Co. Mr. Bennett was formerly with the Alliance Manufacturing Co. in Alliance, Ohio.

WILLIAM C. BENNETT

Paul H. Wilson has been named general superintendent of the Ambridge plant of A. M. Byers Co. Mr. Wilson formerly superintendent of the plant's rolling mill, succeeds **H. B. Linderman** who has



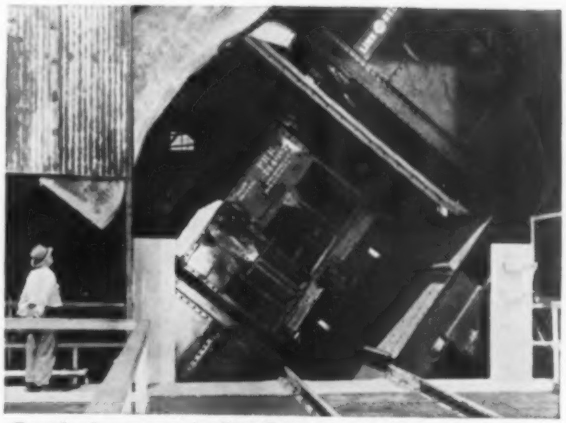
Prior to reaching the storage operation—ore, sinter, pellets or limestone move from car dumper hoppers to Link-Belt rotary feeders. Then the material travels on Link-Belt belt conveyors to the 1900-ft. distributing belt conveyor shown here. This is equipped with a traveling tripper-stacker with 40-ft. boom that can be seen in the background stocking out iron ore. Materials can be individually stacked along its full 1712-ft. travel.

LINK-BELT accepts full responsibility for successful bulk handling operation

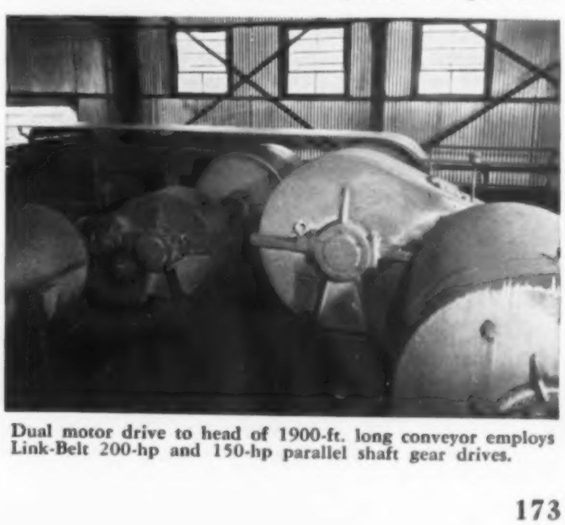
Read how LINK-BELT designed, built and erected unloading and storage facilities for large eastern mill

So satisfactory was the seven-year record of the Link-Belt coal handling system at this large steel mill, they again called on Link-Belt to modernize their other bulk handling. Now, from railroad car unloading to storage, Link-Belt has mechanized the movement of iron ore, sinter, pellets and limestone.

Link-Belt designed, built and erected the complete raw materials handling system for this mill—including such details as enclosures and electrical wiring. When you rely on Link-Belt as a single source, Link-Belt accepts full responsibility for placing your system in successful operation. Our engineers will also work with your own engineers, consultants and builders of mill and process equipment—help you get the best in modern handling of steel and raw materials in every form. For complete information, call the Link-Belt sales office near you.



Completely automatic Link-Belt rotary dumper easily unloads up to 30 hopper-bottom and gondola cars per hour.



Dual motor drive to head of 1900-ft. long conveyor employs Link-Belt 200-hp and 150-hp parallel shaft gear drives.

LINK-BELT

MATERIALS HANDLING, PROCESSING AND POWER TRANSMISSION MACHINERY

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,534 retired. **Daniel A. Schmitt** was appointed superintendent of rolling mills and assistant to Mr. Wilson, and **John F. Luzadre** was named assistant superintendent of rolling mills.

Howard E. Dykeman was named chief engineer of Mellon-Stuart Industrial Construction Co. and **Don E. Benson** was named manager of construction. Mr. Dykeman joined Mellon-Stuart after service as a design engineer with Arthur G. McKee & Co. Prior to that, he was associated with the Jones & Laughlin Steel Corp. where he did design work on J&L's new open hearth department and its foundry expansion program. He also served as chief engineer of the coal preparation division of Heyl and Patterson, Inc., Pittsburgh, and as a design engineer for U. S. Steel Corp. and Koppers Co., Pittsburgh, and Armco Steel Corp. at Butler, Pa. Mr. Benson was construction superintendent for Arthur G. McKee & Co. for four years prior to joining Mellon-Stuart. He also was manager of construction for 13 years for the Freyn Engineering Co. and Koppers Co. after it acquired Freyn Engineering.

HOWARD E. DYKEMAN

DON E. BENSON

Marshal G. Staub, treasurer of Merritt-Chapman

McDANEL
High Temperature
COMBUSTION
TUBES

Give Long Trouble Free Service

McDanel Porcelain Combustion Tubes and Zirco Tubes are precision made. Density, bore size, wall thickness, etc, are carefully controlled to assure maximum resistance to thermal shock, accurate fit and gas tightness. Cast as a single unit, they defy devitrification—give longer service and lower replacement costs. For carbon and sulphur determinations, McDanel Tubes are TOPS.

Refractory Porcelain Specialties in stock or designed to meet specific needs. Flasks, retorts, crucibles, etc. and parts "custom-made" to do the job.

Write Today for Catalog "McDanel Industrial Porcelains"

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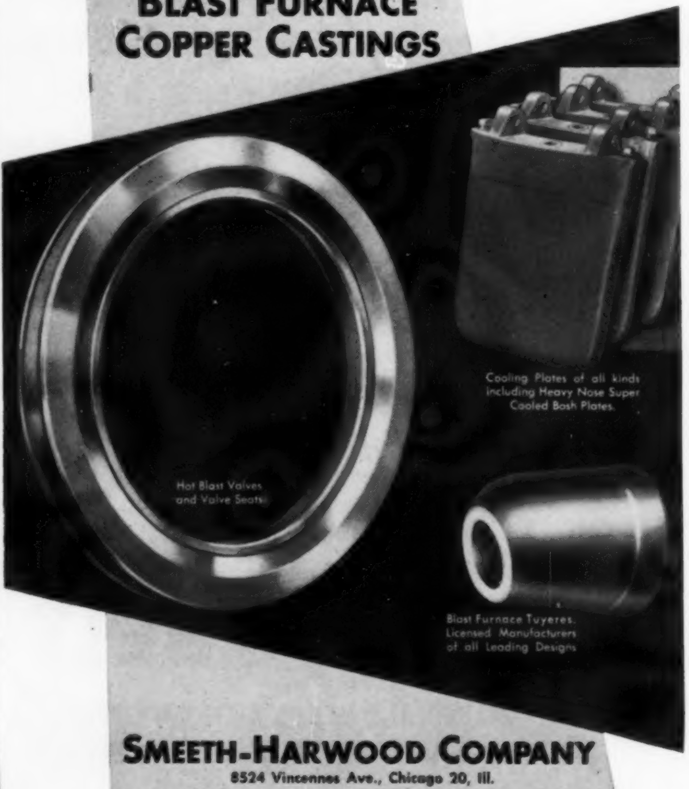
BEAVER FALLS, PENNA.

GRINDING BALL...MILL LINING BRICK...
MILL HEAD ASSEMBLIES...TANK & DRYER LININGS

Superior
BLAST FURNACE
COPPER CASTINGS



Cooling Plates of all kinds including Heavy Nose Super Cooled Bosh Plates.
Hot Blast Valves and Valve Seats.
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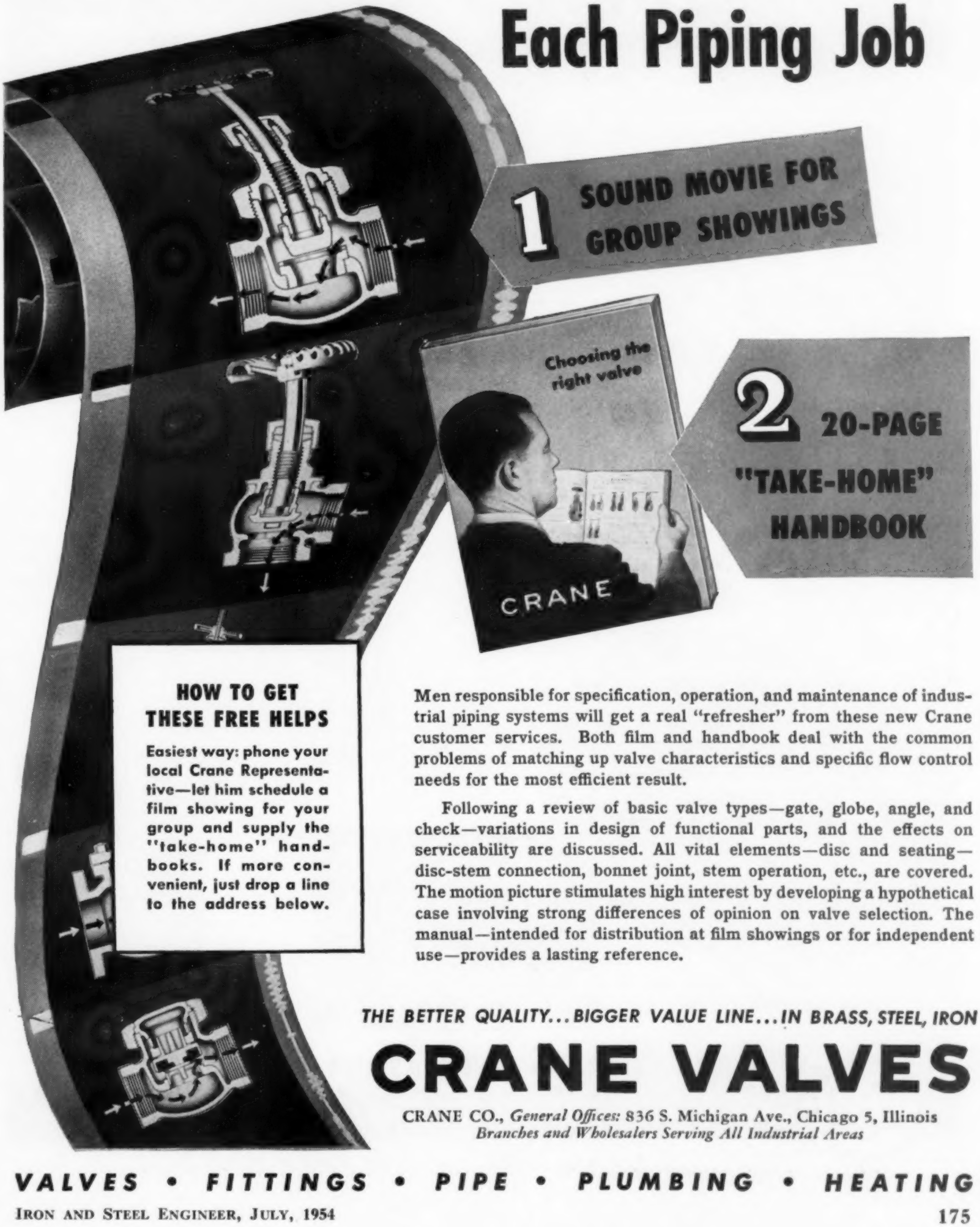
2 New Services from Crane

How to Choose the Right Valve for Each Piping Job



1 SOUND MOVIE FOR GROUP SHOWINGS

2 20-PAGE "TAKE-HOME" HANDBOOK

HOW TO GET THESE FREE HELPS

Easiest way: phone your local Crane Representative—let him schedule a film showing for your group and supply the "take-home" handbooks. If more convenient, just drop a line to the address below.

Men responsible for specification, operation, and maintenance of industrial piping systems will get a real "refresher" from these new Crane customer services. Both film and handbook deal with the common problems of matching up valve characteristics and specific flow control needs for the most efficient result.

Following a review of basic valve types—gate, globe, angle, and check—variations in design of functional parts, and the effects on serviceability are discussed. All vital elements—disc and seating—disc-stem connection, bonnet joint, stem operation, etc., are covered. The motion picture stimulates high interest by developing a hypothetical case involving strong differences of opinion on valve selection. The manual—intended for distribution at film showings or for independent use—provides a lasting reference.

THE BETTER QUALITY... BIGGER VALUE LINE... IN BRASS, STEEL, IRON

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

Put in to Stay in Longer

MOLDIT CASTABLE REFRACTORY

in Annealing Furnace Bases

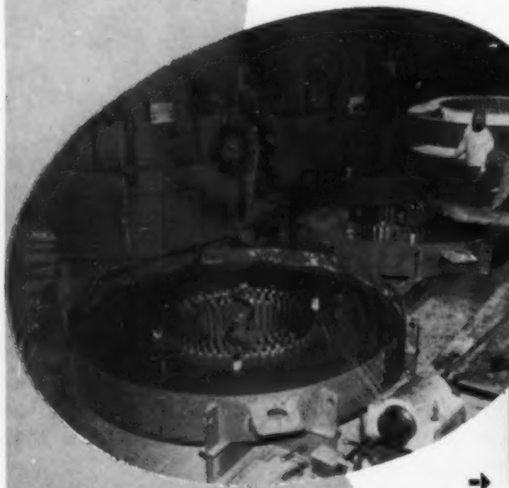
Bases for annealing furnaces made of Moldit D Refractory Cement, with surrounding sand seal area of Light Weight Moldit #80 insulating refractory. This installation cut repairs in half. Not a crack appeared in setting or drying. Has given double the life of other refractory materials.

▶ ***INSTALLED IN HALF THE TIME***

▶ ***OUTLASTS OTHER REFRACTORIES***

Moldit—the pioneer line of castable refractory materials—has been cutting maintenance costs as much as 90% in reheating and annealing furnaces because of its quick installation and long service life.

Easy to pour, trowel or even "gun" into place, in any monolithic section of any shape and size, Moldit air-sets to full refractory hardness and is ready for use in a few hours. There is the right type of Moldit with the right workability and durability for every furnace application. Write for the Moldit story today.



← Circular bases of bell type annealing furnaces being made of Light Weight Moldit #55 insulating refractory, a strong, very economical material for this type of furnace base.

→ Car bottom and piers for steel annealing furnace cast from Moldit Pier Cement.

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REFRACTORY & INSULATION CORPORATION

R&I

Refractory Bonding and Castable Cements — Insulating Block, Blankets, Cements

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& Scott Corp., was elected treasurer and assistant secretary of Newport Steel Corp. Mr. Staub, who has been serving as financial consultant to Newport Steel, will succeed **H. E. Hamilton** as treasurer and assistant secretary.

Ralph T. Shipley was named assistant superintendent of the Timken Roller Bearing Co., Steel and Tube division. He was formerly general plant foreman. **Burke Denison** has been named to the post of general foreman of the Gambrinus Steel Plant No. 2.

RALPH T. SHIPLEY

BURKE DENISON

Charles J. Blair has been appointed assistant superintendent of the Massillon, Ohio, plant of Republic Steel Corp., Union Drawn Steel division. He succeeds **Harry B. Matzen,** who was appointed superintendent of Union Drawn's East Hartford, Conn. plant. Mr. Blair was previously industrial engineer for the five-plant Union Drawn division. He joined Republic in 1928 with the Central Alloy district in Massillon. After serving for five years as assistant district industrial engineer, he transferred to the Union Drawn division in 1945.

Albert R. Frame has been appointed general manager of operations of the A. M. Byers Co. Since joining the A. M. Byers Co. in 1948, Mr. Frame has served successively as assistant to the general superintendent of the Byers plant at Ambridge, as superintendent of the rolling mill and as assistant general superintendent.

WHAT'S NEW AT BRISTOL...

Now... Bristol thermocouples with metal-ceramic protecting tubes

Bristol's new metal-ceramic LT-1 protecting tubes are the most important advance in thermocouple technology in years.

Combining the thermal conductivity and shock resistance of metal with the corrosion and oxidation resistance of ceramic materials, the new protecting tubes will last far longer than ordinary tubes, give you closer control and faster response.

Here are the advantages of the metal-ceramic LT-1's

- Resistance to combustion gases at temperatures up to 3100°F
- Resistance to oxidation in air at temperatures up to 2200°F
- Retention of strength at high temperatures — 1800 to 2500°F
- Greatly superior to most ceramics in resistance to thermal shock
- Resistance to attack by molten metals and furnace slag
- Increased sensitivity — the ⅛ inch wall has a high thermal conductivity

Get the whole story on Bristol's new tubes. Write for Bulletin P1261 today. The Bristol Company, 123 Bristol Road, Waterbury, Conn.

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AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

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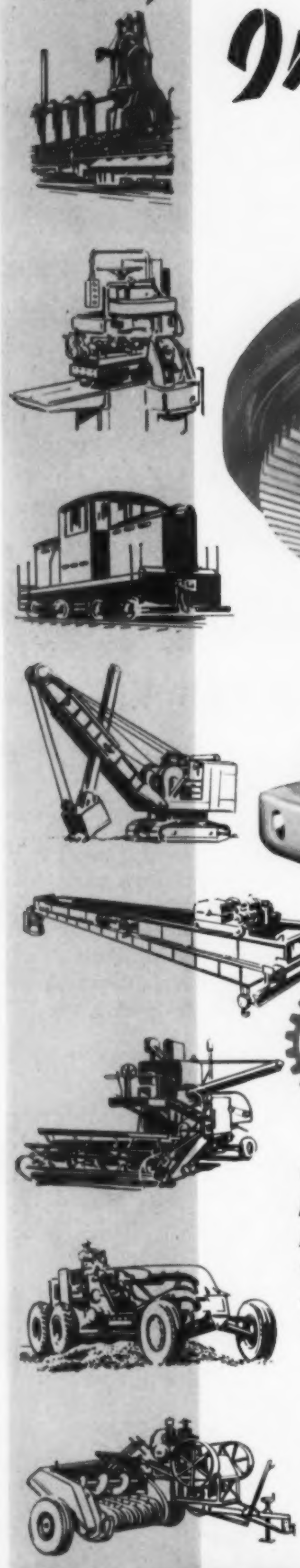

Industrial Cut Gears Serve...

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DRILLING EQUIPMENT

RING GEARS AND PINIONS AS FURNISHED BY "INDUSTRIAL" FOR BREWSTER OILBATH ROTARIES ARE CUT FROM SELECT ALLOY STEEL—SPECIFICALLY HEAT-TREATED TO WITHSTAND HARD OIL FIELD SERVICE.

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DUROCASE GEARS SERVE THE STEEL INDUSTRY — INDUSTRIAL GEAR MFG. CO. CHICAGO

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No easy task drilling through rock, shale, salt and other formations in search of oil. The equipment must be rugged to withstand heavy service requirements.

Industrial Cut Gears were selected by the men of Brewster because they not only met the specifications demanded, but proved superior where extreme loads and shock were encountered on tough drilling jobs.

You, too, will find "IG-Durocase" (Steel Mill Type) or "IG-General Service Gears" *better* for driving your equipment. Send us the next order.

MEMBER OF AGMA

Industrial Gear Mfg. Co.

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He has been associated with the iron industry throughout his career. He started with the Pencoyd Iron Works, Philadelphia, and was later employed by Weirton Steel Co., and by Atlas Steel Co., Ltd., Welland, Ontario, Canada. Prior to joining the A. M. Byers Co. he served as superintendent of rolling mills of the Brazilian National Steel Co. at Volta Redona, Brazil.

J. G. McDonnell has recently joined the staff of S. P. Kinney Engineers, Inc., in an engineering and sales capacity. Mr. McDonnell has been associated with Weirton Steel Co. for the past six years in their metallurgical, fuel and combustion, and blast furnace departments.

J. G. McDONNELL

G. A. Caldwell has been appointed engineering and service manager for Westinghouse Electric Corp., Detroit district. Mr. Caldwell already was engineering manager for the district and now assumes the duties of retiring service manager, **A. J. Koetsien.** At the same time, **F. C. Fennell** was appointed engineering supervisor of the Detroit district. He previously served in the industry engineering department at East Pittsburgh, Pa. Mr. Caldwell joined Westinghouse in 1927. In 1928 he was assigned to the control engineering department, and a year later to the steel mill section of the industry engineering department. He was transferred to the general mill section of that department in 1942 and

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FANS

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6-blade

for spot cooling
of men and machines
drying • exhausting • general ventilating

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other models for every air-moving requirement

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Corrugating and Complete Line of Culvert Equipment—Slitting and Coiling Equipment for Ferrous and Non-Ferrous Material in All Capacities—Warehouse and Steel Mill Cut to Length Lines for Shearing and Levelling Sheets from Coils—Shears for Shearing Sheets and Plates Both Underdriven and Overdriven Types in all Capacities up to 1¼" plate.

STAMCO, Inc., New Bremen, Ohio

Vapor-tite
designed for
rugged service

- Versatility — 4 hubs, 3 plugs
- Resilient neocork gasket
- Extra strong socket, big terminals
- Globe — clear, colored, or heat resisting
- Cast guard with safety groove . . . and it can't rust — it's aluminum alloy for lowest maintenance. Reflectors in all types

Request Bulletin E.

THE ADALET MANUFACTURING CO.
14300 LORAIN AVE.
CLEVELAND 11, OHIO

became its manager in 1944. Mr. Caldwell was named manager of industry control engineering in 1947 and was appointed engineering supervisor of the Detroit engineering and service department in 1950.

Dale B. Kennedy has been named plant manager of the Electricweld Tube division of Jones & Laughlin Steel Corp. at Oil City, Pa. **William Roesch** was named general plant foreman to succeed Mr. Kennedy. These management changes follow the recent death of **H. W. Maskrey,** who was general manager of the division. Mr. Kennedy joined J&L in 1946 as a metallurgical investigator. He became plant metallurgist and chief inspector in 1947 and was named general plant foreman in 1951. Mr. Roesch joined J&L in 1946 as a mechanic at the Vesta No. 5 mine. He was named a construction engineer in the general office in 1950 and became plant engineer and maintenance supervisor at the Oil City plant in 1951.

Rosser L. Wilson was appointed vice president in charge of engineering, and **Robert B. Pogue** was named consulting engineer of the Brake Shoe & Castings division of the American Brake Shoe Co.

Obituaries

Nathaniel R. Richardson, 56, vice president and works manager of the Electric Controller & Manufacturing Co., died June 14. Mr. Richardson joined EC&M in 1924.

Switch, Fuse
AND
Circuit Breaker
PYLETS

WFR Series Safety Switch Pylets

CKJ Series Circuit Breaker Pylets

For Reliable Service Under Most Severe Industrial Plant Operating Conditions

Heavy duty safety switches, fuse boxes with or without plug receptacles, and circuit breaker Pylets provide for reliable service under the most severe industrial plant operating conditions. WFR series safety switch Pylets have heavy cast metal case and cover, quick make and break mechanism interlocked with cover and with plug receptacle, and weathertight gaskets on both cover and hub plate. Safety switches without interlocking plug receptacles are also available. Circuit breaker Pylets, CKJ Series, are but one of the complete line of fuse and circuit breaker fittings, which offer features of sound design and substantial construction to assure reliable service. Consult your Pylet catalog 1100, Bul. 1150 for complete listings.

CONDUIT FITTINGS • FLOODLIGHTS

SINCE 1897

THE PYLE-NATIONAL COMPANY
1383 NORTH KOSTNER AVENUE, CHICAGO 51, ILLINOIS

LESS DOWN TIME...

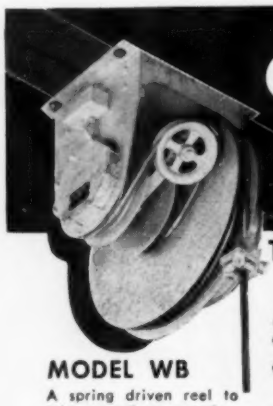
STRAINER
CAP
LARGE DIAMETER ORIFICE

when you CHANGE over to
SPRAYING SYSTEMS descaling NOZZLES

If you want to materially reduce down time on rolling mills due to clogged nozzles, try Spraying Systems descaling nozzles. Large orifice diameter permits passage of practically all particles that ordinarily clog other types of nozzles. Spraying Systems nozzles produce an effective uniform flat spray, free of streaks, with an impinging force equal to over 96% of the maximum potential. Typical user is the Homestead District Works of U. S. Steel illustrated above. Nozzles are made of hardened stainless steel in a wide range of capacities and spray angles. Your inquiry is invited . . . write for Data Sheet 3997.

SPRAYING SYSTEMS CO.
3262 RANDOLPH STREET • BELLWOOD, ILLINOIS

Also write for Data Sheet 4516 . . . Pneumatic Atomizing Nozzles for direct spray gear lubrication.



GLEASON REELS

The Model WB
positively eliminates
- UNDUE CABLE TWIST
- SLIDING CONTACTS AND COLLECTOR RINGS
- UNNECESSARY CABLE LENGTH
- EXPLOSION HAZARDS

ALL-STEEL WELDED CONSTRUCTION

BALL BEARINGS — for smooth, friction-free action.

SPRINGS — best spring steel, mounted outside spool in dust-tight housing. Easily accessible for service or inspection.

TWO-WAY PAYOUT—design permits cable to pass around spool from one side to the other as center of travel is passed. This prevents bends in the cable and requires cable length to be only one-half the length of travel.

SEND FOR LITERATURE DESCRIBING THE COMPLETE GLEASON REEL LINE

MODEL WB

A spring driven reel to take up and pay out electric cords and cables. Used with portable or movable communication or instrumentation equipment which would be adversely affected by the varying resistance of sliding electrical contacts or where undue twisting of cords or cables cause varying capacity. Outstanding applications include pyrometers and crane scales. Also for use in hazardous locations where electrical parts would require dust-tight or explosion proof protection.

Gleason Reel Corp
Subsidiary of Maysteel Products, Inc.
Room 706
740 N. Plankinton Ave. • Milwaukee 3, Wisconsin

to cut refining costs of steel...

A major contribution to the Steel Industry

Kaiser Engineers Acquires Exclusive U.S. Rights to the Oxygen Converter Process*

LIBERTY
IN GOD WE TRUST
1918

Open hearth quality at Bessemer cost

Kaiser Engineers has acquired the U. S. Rights to design, construct and license this new proven European process to produce high quality steel.

Recognized as a significant development in steel making, the *Oxygen Converter Process* (Brassert Oxygen Technique) is producing steel of open hearth quality with production rates, thermal efficiencies and low cost comparable to the Bessemer Converter.

Tailored for the U. S.

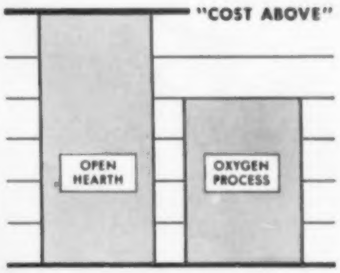
Extensive metallurgical studies show that oxygen steel meets the exacting demands of U. S. fabricators. Kaiser Engineers has solved the problems incident to American practice and is prepared to offer a complete *Oxygen Converter Process* and auxiliaries designed for the American Steel Industry. Such auxiliaries include not only the tonnage oxygen plants but facilities especially designed for the collection and treatment of dust laden gases.

Advantages:

Compared to open hearth practice, the advantages of the *Oxygen Converter Process* include low capital investment, low operating cost and definite savings in both installation space and auxiliary equipment.

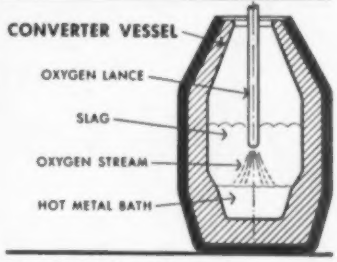
Compared to an air-blown Bessemer Converter, the high thermal efficiency of the *Oxygen Converter Process* permits the charging of larger percentages of scrap (up to 3 times as much) than normal converter practice.

* From Brassert Oxygen Technique—Zurich, Switzerland



Operating Cost

The U. S. practice for the Oxygen Converter Process has been calculated to produce a net saving of $3.00 per ton in "cost above" over the average "cost above" for the open hearth process.



Production Rate

In a Bessemer-like vessel, high purity oxygen is impinged directly onto the top of the molten metal bath. 35-ton heats are being produced at the rate of 1½ heats per hour.

Investment

One 35-ton oxygen converter will match in production capacity three 175-ton open hearth furnaces at half the estimated capital cost.

kaiser | engineers *...for low operating costs*

DIVISION OF | HENRY J. KAISER COMPANY

ENGINEERS — CONTRACTORS

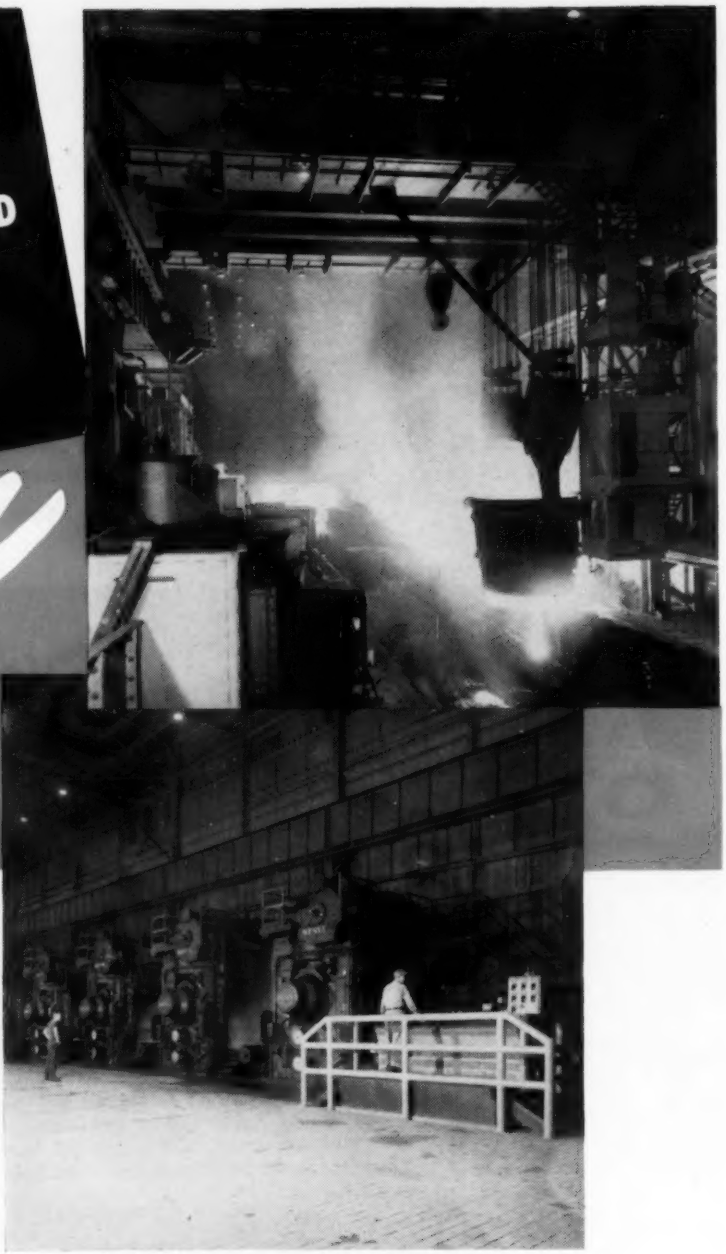
HOME OFFICE: KAISER BUILDING, OAKLAND 12, CALIFORNIA (CABLE: KAISENGS) NEW YORK, PITTSBURGH, LOS ANGELES, WASHINGTON, D. C.
HENRY J. KAISER CONSTRUCTION CO. • HENRY J. KAISER COMPANY (Canada) LTD., MONTREAL

OVER 20,000 BEARINGS ARE LUBRICATED AT FAIRLESS WORKS BY

Trabon

LUBRICATION SYSTEMS

LUKE THE LUBRICATOR



PHOTOS COURTESY U. S. STEEL CORPORATION

The following wide range of equipment at U. S. Steel's new Fairless Works is lubricated around the clock by TRABON *positive* lubrication systems: Wellman Ore Bridge; E. W. Bliss Hi Scale Breakers; Arthur G. McKee Blast Furnaces; Atlas Ore Transfer Cars; Wean Combination Line; Alliance Cranes; Cleveland Cranes; American Bridge Cranes; Wellman Charging Machines; Dravo Ore Unloaders; E. W. Bliss 80″ Pickle Line; Mesta 45″ Slabbing Mill; Mesta 80″ Hot Strip Mill; Morgan 10″ Merchant Mill; Continental 40″ Blooming Mill; United Billet Mills; Morgan Scale Yard Crane; E. W. Bliss Cold Mills.

This installation of TRABON systems, automatic and manual, assures each bearing point accurate lubrication as frequently as it is required. Not a bearing is under-lubricated or skipped, thus eliminating costly equipment breakdown and bearing loss.

Write for our detailed literature for further information on TRABON versatile, trouble-free lubrication.

Trabon ENGINEERING CORPORATION
1814 E. 40th STREET • CLEVELAND 3, OHIO
Oil and Grease Systems

Equipment News...

GAS-POWERED TRUCK

▲ The first approval and listing for a fork-lift truck powered by liquified petroleum gas has been granted by Underwriters' Laboratories to Clark Equipment Co.

The unit, designated as the LPG-Carloader, is a standard model fork truck in 3000-5000 lb capacities, equipped with conventional dynatork or hydratork transmission, factory-modified for LPG operation. Installation of a compact, field-tested "fuel unit" and relatively minor engine changes adapt the gasoline-powered fork truck for LPG.

LPG, in normal commercial usage a mixture of butane and propane under pressure, is a desirable fuel because it burns clean without giving off obnoxious fumes and leaves no unburned carbon, lead compound or varnish deposits. Because it is dry gas, there is no liquid to dilute the cylinder lubricant or crankcase oil. The result is less wear on cylinder walls and bearings, and longer life for the lubricating oil.

The fuel unit developed by Clark consists of a heavy-duty fuel tank, vaporizer-regulator and a simple, rugged air-gas carburetor. The system draws fuel from the tank in liquid form and is vaporized before it reaches the manifold.

Since the fuel is under its own pressure at all times in the tank, the need for a fuel pump is eliminated. A solenoid valve automatically opens or closes the fuel line by the ignition switch, and serves as a positive lock-off when the engine is stopped. As another safety precaution, a vacuum switch has been placed between the ignition and the manifold which prevents fuel from being drawn into the engine until the engine is turned over.

The engine is modified to operate at a high compression ratio (8 to 1) to take better advantage of LPG's higher octane rating and to provide maximum efficiency, fuel economy and engine power. Also, a cold intake manifold is used, since the fuel is already a gas when it enters the manifold and does not require a hot spot as does gasoline.

To refuel, the fuel tank is removed in a matter of minutes and simply hooked to the LPG storage unit and fuel pumped in; a hand pump can also be used effectively. Spare tanks are available if it is desired to keep a stand-by full tank. The fuel tank is rated at 1600 lb pressure, and is equipped with a safety-relief valve which by-passes pressure in excess of 275 lb.

ELECTRO-MAGNET

▲ A line of small electro-magnets to be used with mobile materials handling systems is announced by the Electric Controller & Manufacturing Co. These magnets can be used with boom-equipped gas or electric industrial trucks and in some applications, magnets can be attached to lift truck forks.

The magnets will lift coiled stock, castings, billets, pipe, slabs and batches of small parts as well as loose scrap. Accurate positioning of machine stock or large castings on machine tools or grinders can be accomplished, and the handling of large dies for molding machines is simplified by use of magnets. Manual handling of hot castings or forgings can be eliminated as the magnets transport them safely and quickly anywhere in the plant.

The magnets can also be used for batch weighing operations and for fast efficient delivery in intra-building materials handling systems.

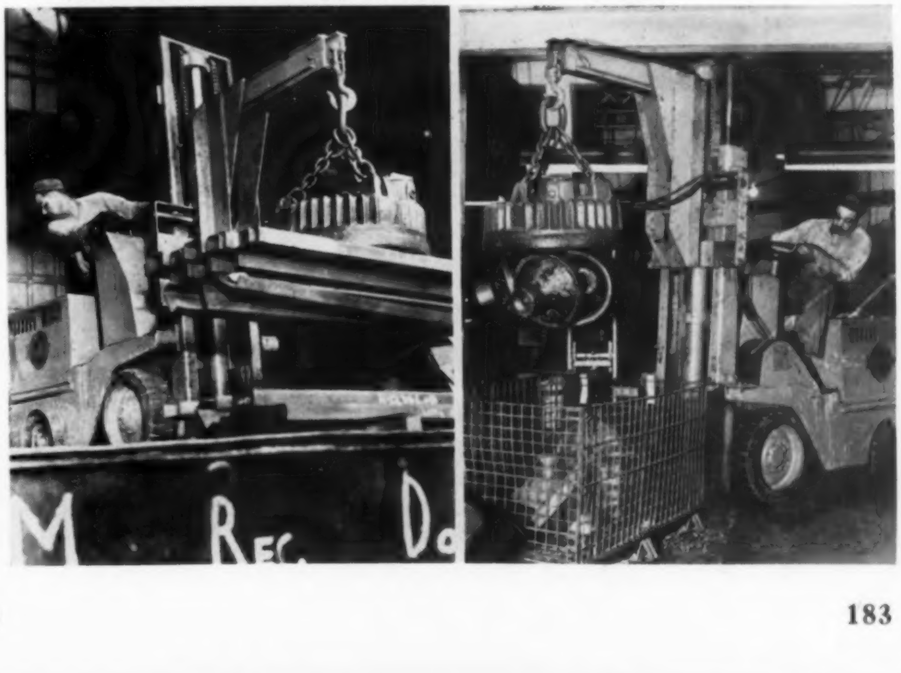
When not in use as lifting and transporting units, the magnets can be utilized as floor type sweepers for ferrous scrap.

The electro-magnets are furnished in sizes ranging from 12½ to 36-in. in diameter, weighing from 155 to 1900-lb. While larger size units are available for use in the heavier duty industrial cranes, the smaller magnets are recommended for intermediate duty materials handling operations. As example, the 24-in. diameter magnet weighing 690-lb will lift a 6,000-lb billet or slab; 200-lb of machine cast pig iron; 150-lb of cast iron borings or 75-lb of steel turnings.

The 29-in. diameter magnet weighing 1390-lb will lift a 13,000-lb billet or slab; 550-lb of machine cast pig iron; 350-lb of cast iron borings or 175-lb of steel turnings. These are conservative lifting figures based on the average lift obtainable under normal conditions during an all-day cycle. When magnets are not operated continuously or when material is stacked uniformly the lifting will be considerably higher.

All of the magnets feature bottom plates welded in place. Continuous welds between the inner and outer

Designed for mobile materials handling systems, this electro-magnet attachment eliminates numerous manual handling operations. It will also prove useful as a floor type sweeper for ferrous scrap.



circumference of the bottom plate and the magnet case provide watertight seal. Single conductor, rubber armored cables are brought out of the terminal boxes through compression, glands, and are secured to the magnet case by a strain clamp. Terminal boxes are filled with Cardolite compound.

CONTROL STATION

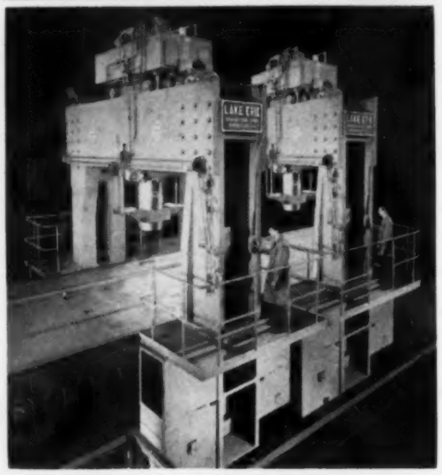
▲ Available from the Bailey Meter Co. is a new control station that provides a complete picture of control system performance and full flexibility of remote control.

An operator has the choice of remote manual control independent of all automatic controllers for starting and stopping the process and for periods where the measuring and/or controlling elements may be out of service. Quick transfer from automatic to hand may be made without any disturbance to the process.

Vertical gages indicate signals from the transmitter, set point or bias, hand control, and automatic control. The three control knobs are for automatic-hand selection, set point or bias adjustment, and hand control.

This unit operates on standard SAMA signal ranges of 3-15 or 3-27 psig. Gage accuracy is within ±½ per cent of signal range, and air consumption is less than 0.2 cfm.

TWIN CARRIAGE PRESS



This 2000-ton twin carriage traveling head press, built by Lake Erie Engineering Corp., is used to straighten castings measuring 22 ft by 10 ft and weighing over 46,000-lb. The twin traveling heads each deliver 1000 tons force by means of a 5000 psi pump and a 50-hp motor. Individual carriages allow independent longitudinal movement and each traveling head can be transversely positioned to meet requirements. Each of these operations is accomplished at 120-in. per minute by separate gear motors. With this control and travel, straightening operations over a 267 sq ft area are permitted.

WELDING UNIT

▲ The Utica Drop Forge & Tool Corp., has announced the KB-14 and KB-14B Buttweld tools as the only standard Koldwell Buttweld tools on the market.

These tools will Buttweld different sizes of same or dissimilar non-ferrous metals together without the use of heat, electricity or chemicals. Yet, they can be operated by unskilled personnel.

The tools are "plier action" operated. They weigh just five lb and are 14-in. in length. The manufacturer states that these tools can produce faster and better welds than the conventional type. Extensive tests conducted in at least a dozen leading wire mills, on high speed equipment, have proven the superior strength of welds produced by Buttweld tools.

The KB-14B tool will Koldweld Buttweld aluminum and copper, and aluminum to copper wire in a range from .039-in. (No. 18 gage) up to but not including .063-in. (No. 14 gage, .064-in. nominal).

The KB-14 tool will handle copper wire from No. 14 gage up to .089-in., (No. 11 gage, .091-in. nominal). The KB-14 will handle aluminum and aluminum to copper wire in a range No. 14 gage up to .127-in. (No. 8 gage, .128-in. nominal).

SPEED REDUCER

▲ Available from the Westinghouse Electric Corp. is a new line of large industrial speed reducers.

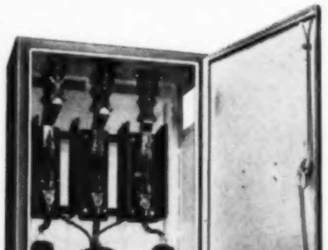
The line consists of a series of single- (Type WSH) and double-reduction (Type WDH) units. Thirteen standard ratios from 2.24 to 9.21 are available for WSH; sixteen ratios from 11.3 to 70 are available for WDH.

The speed reducers are of the external geared type with shafts arranged in a horizontal plane, resulting in high efficiencies. The design incorporates compact, rigidly constructed fabricated gear cases, pre-

QUALITY
and
SERVICE
more
tonnage
per
edge
A
AMERICAN
SHEAR KNIFE CO.
HOMESTEAD • PENNSYLVANIA

OUT OF BUSINESS
3 HOURS!...

...FOR WANT OF SHORT CIRCUIT PROTECTION



EC&M Valimitor Starters provide unlimited short circuit protection for 2200-5000 volt motors.

2008

EC&M Motor Starters could have prevented this work stoppage . . . the costly downtime, the delay, the repairs. Unlimited protection against fault currents, regardless of their magnitude, is assured by the Valimitor Starters (volt-ampere-limitor) for 2200-5000 volt motors.

When you install these Valimitor Starters, there is no need to calculate existing KVA . . . no problem of estimating future requirements. These unique Motor Starters will limit the maximum fault current to 25,000 KVA, even if the bus has infinite capacity.

In addition to the Valimitor type, EC&M Motor Starters are available in 50,000 KVA interrupting capacity. Both can be supplied with weather-resistant, explosionproof, or other enclosures to meet any operating conditions.

Whatever your requirements, EC&M Motor Starters will provide the protection you need against losses caused by fault currents.

Any way you figure it . . . short circuit protection is your best buy!

Write today for Booklet 1062 for complete details.

THE ELECTRIC CONTROLLER & MFG. CO.

2698 EAST 79th STREET • CLEVELAND 4, OHIO cision gears and pinions, antifriction bearings, and liberal-sized shafts.

STAMPING MACHINE

▲ Designed for low cost production stamping, a new marking machine developed by M. E. Cunningham Co., will stamp almost any size of round part.

The unit, model GRD-950-1, consists of four primary elements: a cast steel base, with side flanges for bolting to a bench; an arbor for holding the pieces to be marked; a roller marking die; and a gear-mounted handle. When the handle is turned, the gear arrangement causes the die to rotate with the piece held in the arbor, with the lettering rolling into the part.

The roller marking die may be either solid or insert style. Type capacity depends on size of character to be used. Either single characters or logotypes may be fitted into insert style dies.

Arbors are furnished for any size of tubing, but it is not necessary to use a different arbor for every inside diameter size.

Needle bearings are used with all moving parts. A fine screw adjustment is provided to allow for setting depth of impression, and set screws lock the unit in position after it is set up for pieces to be marked.

Book Reviews . . .

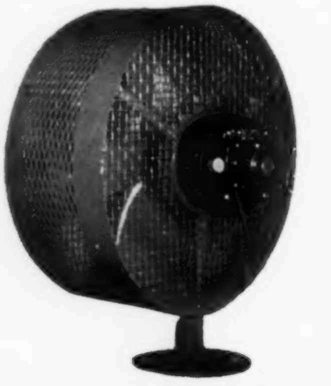
▲**"Machinery's Handbook,"** by Erik Oberg and Franklin D. Jones was republished in May 1954 in a 15th edition by The Industrial Press, 148 Lafayette St., New York 13, N. Y., 4½ x 7 in., leather bound, 1911 pp., price $9. This 15th edition provides a standard reference for mechanical industries. Printed in clear, concise, ready-to-use form, the book provides the new and hard-to-get as well as the established standard data and information needed by machine designers, shop management, skilled mechanics, engineering students and students in shop training courses. The book is an invaluable aid where anything mechanical is designed or constructed.

▲**"MAPI Replacement Manual,"** prepared by Machinery and Allied Products Institute, 120 South La Salle St., Chicago 3, Ill. is a practical working tool for the buyer's managerial and operating organization, and for the sales force. It is 9¼ x 6-in., contains 75 pages, and sells at $3 per single copy, with lower prices for quantity orders.

This manual is a comprehensive handbook recommended for the attention of all persons having questions on replacing equipment and for machinery users, machinery sellers, professionals and colleges. It is a practical answer to a key problem of management policy.

▲**"Quality Control,"** by N. L. Enrick, a second enlarged edition was recently published by The Industrial Press, 148 Lafayette Street, New York 13, N. Y., 6 x 9-in., 181 pp, cloth bound, price $4. This manual is prepared to be a practical and usable reference with emphasis on clarity of directions and simplicity of methods. Many new pages of text, tables and charts have been added to this edition. Contents include ready made sampling plans, sample control charts, com-

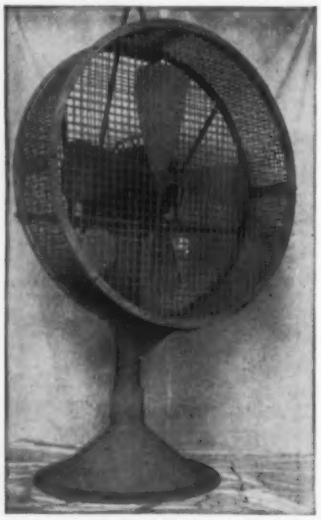
IS HEAT SLOWING UP YOUR WORKMEN?



TRUFLO CRANE CAB FANS
For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 in. sizes.

Keep them COOL

with TRUFLO FANS



TRUFLO PORTABLE COOLING FANS
Easily portable. Help keep efficiency high where work is hottest. 12 to 36 inch diameters.

Production suffers when workmen are overheated. Steps begin to drag, efficiency falls.

Now, when speedy production is vital, Truflo Fans can help keep your workmen on their toes. All Truflo Fans are designed and built correctly to put fresh cool air *in large volumes* exactly where it is needed. Perfectly-balanced shafts and blades give more air per h.p. . . . strong steel frames stand up longer under hard use . . . rugged wire guards protect men against injuries.

All of the following types can help beat the heat, keep production moving in your plant. Write for illustrated literature.

PORTABLE COOLING FANS
CRANE CAB FANS • WALL FANS
EXHAUST FANS • BLOWERS
ROOF VENTILATING FANS
· PENT HOUSE FANS

TRUFLO FAN COMPANY

245 MAIN ST. HARMONY, PA.

THE MODERN METHOD OF INCREASING SIZE OF BUNDLE

VAUGHN®

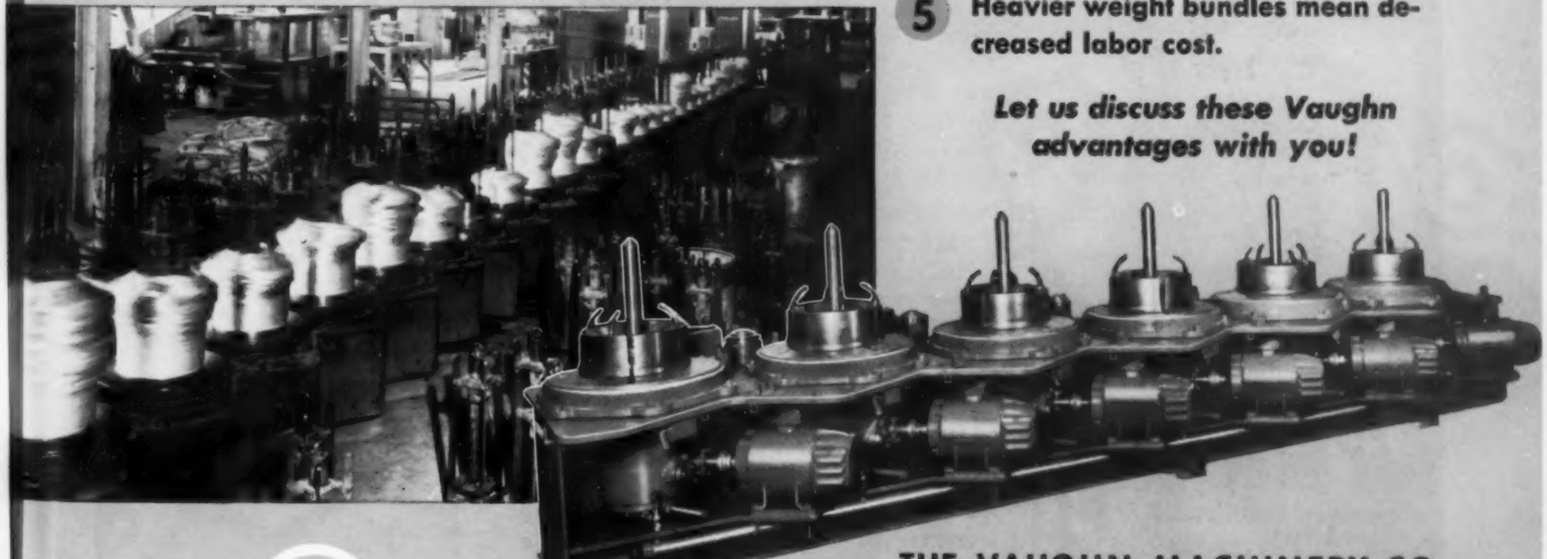
TAKE-UP UNITS

FOR PATENTING AND GALVANIZING

Note these Features!

1. **Individual motor drive—with slow down feature for stripping.**
2. **Push up blocks.**
3. **High riding stripping spider provides a pay-off stand for subsequent processing, and**
4. **automatically reduces pay-off tangles and handling costs.**
5. **Heavier weight bundles mean decreased labor cost.**

Let us discuss these Vaughn advantages with you!



"Quick on the Draw!"

THE VAUGHN MACHINERY CO.
CUYAHOGA FALLS, OHIO, U.S.A.

COMPLETE COLD DRAWING EQUIPMENT—Continuous or Single Hole . . . for the Largest Bars & Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

Hyde Park

RED CIRCLE Rolls ALLOY-CHILLED

Red Circle Rolls for all Purposes

Hyde Park Red Circle Rolls are outstanding in quality and in performance and are easily identified by the Red Circle.

for
finer finish
long life
greater tonnage
Specify Red Circle

Chilled Rolls
Alloy Iron Rolls
Moly Rolls
Nickel Chilled Rolls
Grain Rolls
Cold Rolls
Sand Rolls

Hyde Park
FOUNDRY & MACHINE CO.
Hyde Park, Westmoreland County, Pa.
ROLLS
ROLLING MILL MACHINERY
GREY IRON CASTINGS

pressed limit gages, basis of proper specifications, problems of old equipment, and theory.

▲**"Induction and Dielectric Heating,"** by J. Wesley Cable has been recently published by Reinhold Publishing Corp., 330 West 42nd Street, New York 36, N. Y., 6 x 9-in., 576 pp., cloth bound, price $12.50. This book offers a carefully organized treatment of the latest uses and applications of high-frequency heating in industry, and contains sufficient theory to give a full understanding of such heating. Book is divided into two major sections with each containing fundamental theory and operating principles of equipment used as sources of electrical energy for high-frequency magnetic and dielectric fields. A complete coverage of coil and electrode design is presented along with the construction of mechanical jigs and fixtures and work handling methods.

▲**"Fundamentals of the Working of Metals,"** by G. Sachs is a recent book published by Interscience Publishers, Inc., 250 Fifth Avenue, New York, N. Y., 8½ x 5½-in., 158 pp., with cloth binding, price $4.75. This book presents an elementary description of the basic phenomena which determine the performance of metallic materials in mechanical working and it attempts to present a simple discussion of basic facts which determine the success or failure of forming operation. These principles apply both to fabricating and processing of metals.

"Japan's Iron and Steel Industry, 1953-54 Edition," edited by Sukeyuki Kawata of Tokyo Foreign Service was recently published by Tokyo Foreign Service, No. 7, 2-Chome, Yuraku-Cho, Chiyoda-Ku, Tokyo. The book contains 200 pages of illustrated statistics and charts for the industry, 7 x 10-in., paper bound, price including postage by surface mail is $3, or equivalent. Airmail requires additional charge. This edition presents articles of presidents of the six largest iron and steel producing companies in Japan; and a review of developments in 1952 and 1953, and data on the modernization program, market conditions; data on government subsidies, schedules of production and requirement for 1954, etc.

(*Please turn to page 192*)

Get this Free Handbook
COMMUTATOR and SLIP RING MAINTENANCE
. . . a handbook of procedures and methods
IDEAL

for **MAINTENANCE MEN**
INSTRUCTORS
and TRAINEES
in Motor Maintenance

THE methods and procedures described were developed by recognized, practicing maintenance authorities. They have been proven by conclusive evidence over many years in hundreds of operations. A concise guide, this 39-page handbook tells the practical operating man everything he needs to know about:

- **Commutator and slip ring troubles and how to correct them.**
- **Brush maintenance and operating procedure.**
- **General maintenance procedure.**

Dozens of illustrations show the operations described. Condensed data on IDEAL commutator and slip ring products is included.
Even if you do not have a regular maintenance training program, your people responsible for motor and generator maintenance need, and will do a better job, with the help of this handbook.

NOTE: This offer is limited to those in plant and other industrial operations. We reserve right to limit quantities furnished. Offer may be withdrawn at any time.

IDEAL INDUSTRIES, Inc. IDEAL
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Please send ________ copies of your free handbook on commutator and slip ring maintenance.

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Title________________
Company________________
Address________________
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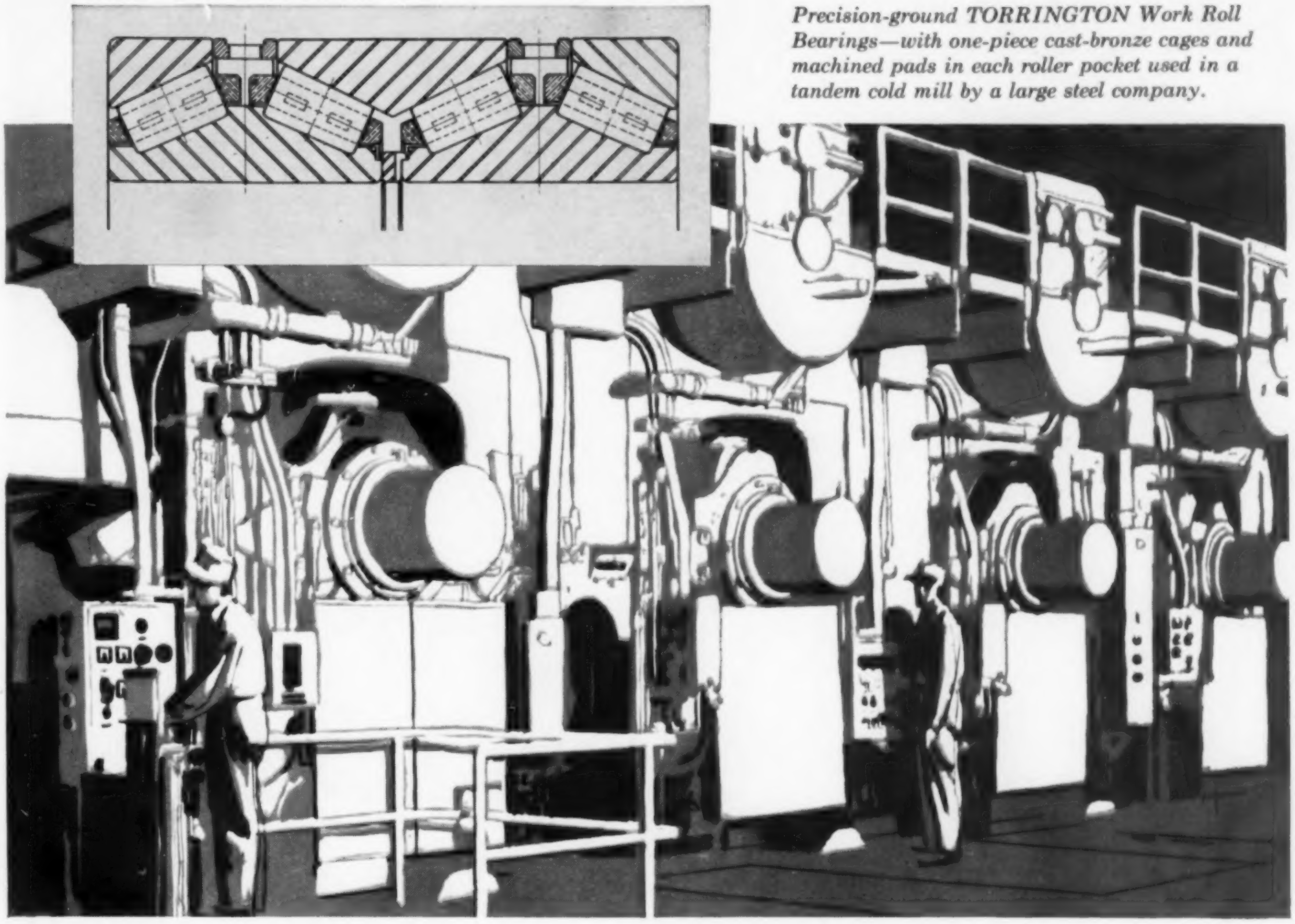
TORRINGTON BEARINGS AT WORK

Precision-ground TORRINGTON Work Roll Bearings—with one-piece cast-bronze cages and machined pads in each roller pocket used in a tandem cold mill by a large steel company.



Built to cut your costs per ton!

Today as never before, lower costs per ton start with the right roll-neck bearings. That's why we say *specify TORRINGTON!*

You'll find in TORRINGTON Bearings the special design features that keep you ahead of today's fast increasing loads and speeds . . . the carefully heat-treated electric-furnace alloy steels that give you maximum toughness, hardness, stability and uniformity . . . the precision tolerances and finishes that give you low eccentricity, uniform load distribution, and minimum friction.

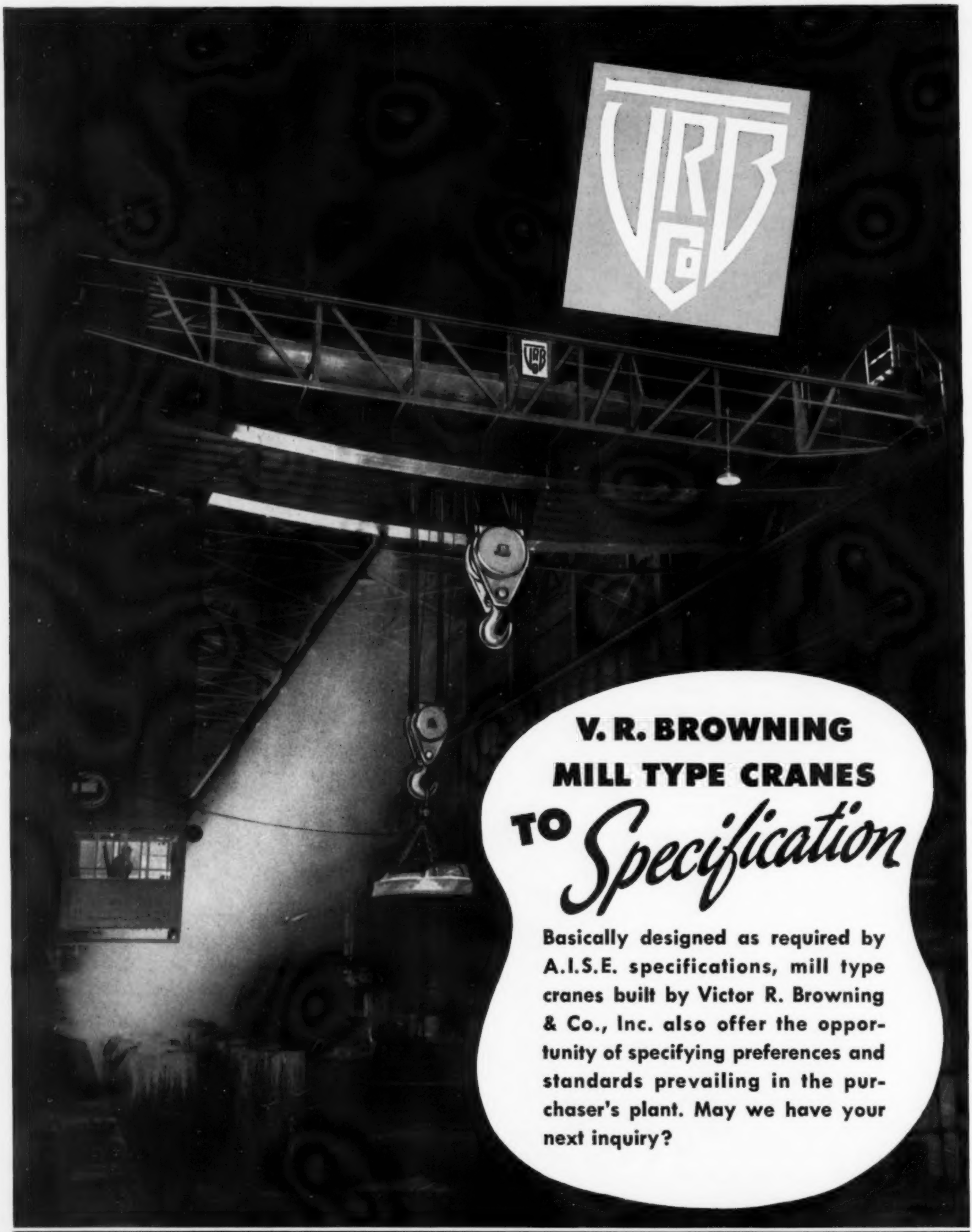
Equally important, you'll find in TORRINGTON's wide range of types and sizes just the bearings you need to handle virtually any combination of thrust and radial loads—smoothly, efficiently, economically.

So specify TORRINGTON for *all* your bearing applications. Your lower costs per ton will prove to you *it pays!*

THE TORRINGTON COMPANY
South Bend 21, Ind. Torrington, Conn.

TORRINGTON *TAPERED ROLLER* **BEARINGS**

Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers



V. R. BROWNING MILL TYPE CRANES

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BOOK REVIEWS

(*Continued from page 188*)

The book has a guide to importers of Japanese iron and steel, and shows sizes and items of ordinary rolled steel available from various makers. It also contains a directory of makers and exporters.

▲**"Ferrous Process Metallurgy,"** by John L. Bray, was published recently by John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. This book is 6 x 9-in., 414 pp., cloth bound and sells for $6.50. The last volume written by Professor Bray before his death in 1952 stands as a fitting monument to his professional and personal achievements. This college text book contains condensed descriptions of equipment with simple line drawings to avoid confusion which is created by the multiplicity of detail involved in working drawings. The book discusses raw materials, the blast furnace and the various steelmaking practices used by plants in the United States.

▲**"NEMA Standards for Industrial Control, Publication No. IC 1-1954,"** completely revises and supersedes the 1949 edition. It covers (1) control devices, such as magnetic contactors, resistors, autotransformers, reactors, pushbuttons, motor-starting switches and brakes, (2) controllers for induction motors, synchronous motors, steel-mill machinery, cab- and floor-operated cranes, mine hoists and graphic arts machinery, (3) high-interrupting-capacity low- and high-voltage controllers, (4) direct-current general-purpose and machine-tool controllers and (5) control centers. Definitions, device designations and symbols applicable to industrial control equipment are also covered. Book may be obtained from NEMA, 155 East 44th St., New York 17, N. Y., price $6.00.

▲**"NEMA Standards for Network Protectors, Publication No. SG3.1-1954,"** gives information concerning the rating, manufacturing and application of network protectors. A network protector is defined as "an assembly comprising a circuit breaker and its complete control equipment for automatically disconnecting a transformer from a secondary network in response to predetermined electrical conditions on the primary feeder or transformer and for connecting a transformer to a secondary network either through manual control or automatic control responsive to predetermined electrical conditions on the feeder and the secondary network. ($2.50 per copy).

▲**"NEMA Standards for Transformers, Publication No. TR 1-1954,"** contains standards covering the rating, performance, testing, manufacturing, lead markings and connections of single-phase transformers rated 3 to 33333 kva and three-phase transformers rated 9 to 100,000 kva. The terms used throughout the book are defined. ($3.00 per copy).

▲**"NEMA Standards for Power Circuit Breakers, Publication No. SG4-1954,"** covers rating, manufacturing, testing and application. The testing standards have been considerably expanded in this edition and cover both design and routine tests. The book also contains information concerning the installation, operation and care of power circuit breakers, and the terms used throughout the publication are defined. ($5.00 per copy).

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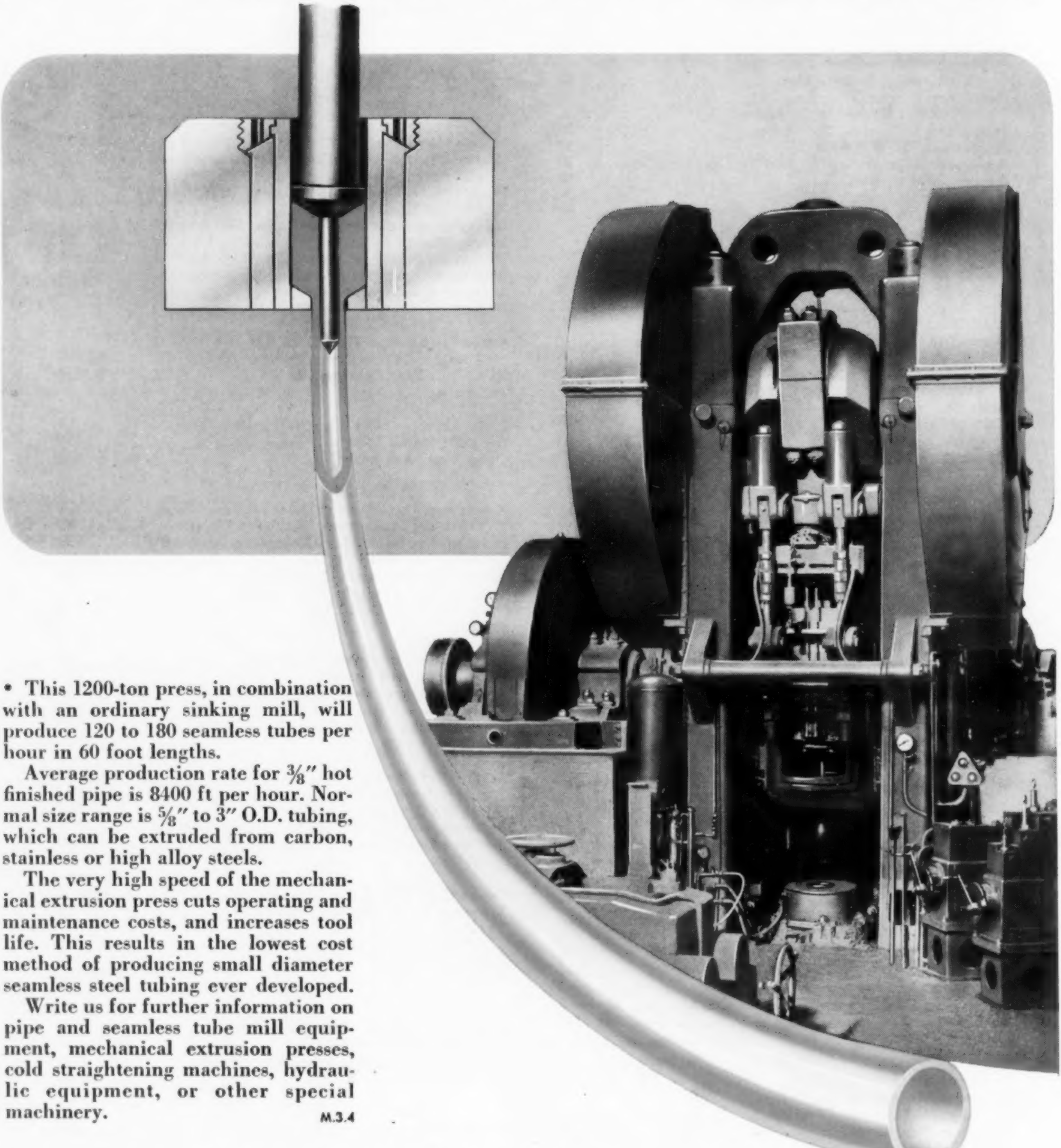

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No. 155

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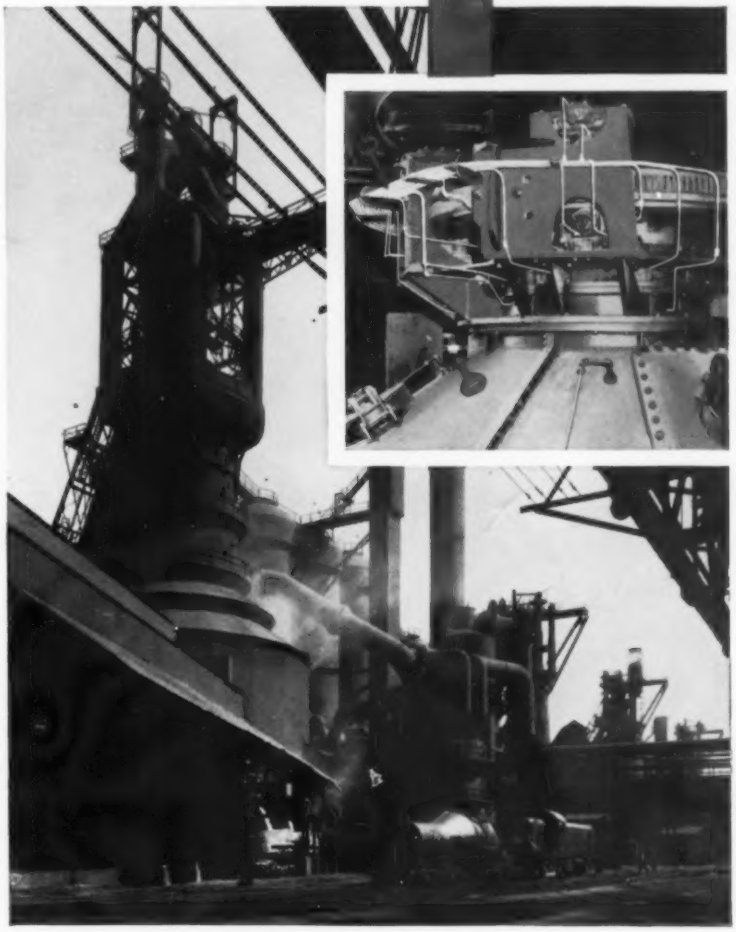

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